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# TRACTOR POWER

on irrigated farms  
in Southern Idaho



UNITED STATES DEPARTMENT OF AGRICULTURE  
Bureau of Agricultural Economics  
in cooperation with  
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## PREFACE

During the three decades from 1920 to 1950, considerable progress was made throughout the country in the mechanization of agricultural production and specifically in the use of mechanical power on farms.

In Idaho the use of tractors on farms has kept pace with that reported for the country as a whole. Somewhat more than 23 percent of all farms in the State reported tractors in use in 1940 and 42 percent so reported in 1945.

Before the introduction of small tractors during the middle 1930's, the use of mechanical power was limited chiefly to farms large in size or in power requirements. Adaptation of mechanical power to small farming units opened a wide field. However, little information is available as to the use of mechanical power under conditions found on irrigated farms. These farms, because of size of operation and particularly because of special operating conditions, have problems in application of tractor power which differ from those on nonirrigated land.

Basic data for this study of the use of tractors on irrigated farms were obtained through personal interview with about 280 farmers in the major irrigated areas of southern Idaho. The farm survey, which covered the availability and use of farm power during the 1940 season, was completed in the summer of 1941. Before the analysis of these data was well under way, more urgent work in connection with the war necessitated extraction of the most needed information for immediate use and the postponement of the major analytical work until after the war.

The study was originally designed to provide physical data regarding the use of tractor power on irrigated farms of family type and to contribute material basic to the efficient use of mechanical power. Through an investigation of the use of power on irrigated farms, information was also to be obtained regarding the proper combination of power and implements and the minimum sizes of operations and farming units of various types on which tractors can be used economically.

The long delay in analysis does not impair the value of physical data collected and the method used in the study is still of interest. The delay does preclude an analysis of all phases in which prices and price relationships are involved, as for instance, the determination of minimum sizes of operations in which tractor power can be economically employed.

## TRACTOR POWER ON IRRIGATED FARMS

## IN SOUTHERN IDAHO

By H. H. Stippler and J. W. Martin 1/CONTENTS

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## SUMMARY

Areas in southern Idaho included in this report in many respects are typical of general farming areas in the West where intensive agricultural production is carried on under irrigation. They do not represent areas in which one or more specialty crops, as fruits, occupy a large part of the irrigated land. In southern Idaho, such characteristics as size of farm, major crops grown, and length of season, vary somewhat by individual areas but these variations are confined to rather narrow limits determined primarily by soil and elevation.

To learn about the use of power in individual field operations, in all operations performed in the production of a given crop, as well as total use on a given farm, it was necessary to express the use of varying types and sizes of tractors and the use of horses by a common denominator. This was accomplished by converting fuel consumption of tractors into horsepower hours and converting horse work into equivalent tractor work. Thus, the use of tractors as well as horses is expressed in horsepower hours.

Of the tractors in use on farms in 1940, almost three-fourths were of the tricycle type and the remainder were primarily standard type machines. Only a few tracklayer-type tractors were in use. The average age of tractors was almost 5 years for tricycle and more than 6 years for tracklayers. A large percentage of the latter were bought second-hand. More than three-fourths of the wheel-type tractors were operated on rubber tires and most of them were bought new. Of those operated on steel wheels, less than half were bought new but the average horsepower rating was 11 percent higher than that of tractors operated on rubber. More than 90 percent of all tractors had a rating of less than 20 draw-bar horsepower, and well over half had less than 15 HP.

Throughout this report the terms "horsepower hours used" and "energy consumption" as derived from gallons of fuel used have been used more or less interchangeably. But it should be noted that these terms must be distinguished from "energy requirements" which are also expressed in "horsepower hours." Energy requirements can be learned accurately through dynamometer tests only. The relationship between energy requirements and energy consumption is touched upon in the discussion on the method of analysis used (page 11) and discussed in greater detail in a chapter beginning on page 65.



In addition, the use of horses in field work in 1940 was rather extensive. Only horses used in field work were considered available power. Their number and average use increased as the size of farm increased. Horses were found on 90 percent of the so-called tractor farms included in this report, while less than 3 percent of the farms did not use horses in field work. On more than 7 percent, horse work was hired or exchanged for tractor work.

On the basis of work accomplished, one horse was found to be equivalent to somewhat more than two drawbar horsepower of mechanical power. Total power for field work, consisting of tractors and horses, increased with size of farm but less than in direct proportion. Thus, on farms of less than 50 acres, as measured by cultivated land, one horsepower was available for every 2-1/3 acres; on farms of 150 to 200 acres, one horsepower was in use for every 6 acres of land.

The use of power in field work was influenced by many factors, of which draft of the implement and speed of operation were most important. Although fuel consumption of tractors was reduced by a lighter load, this reduction was less than in proportion to a decrease in load. Greatest efficiency was obtained when tractors were operated at or near capacity. For lighter loads, the inefficiency in operation was sometimes overcome by an increase in the speed. But for most field work there is an optimum speed which could not be exceeded without reducing quality of work.

In plowing sod, farmers used an average of 0.74 rated horsepower per inch of cut of moldboard plow. This meant using almost 22 horsepower hours per acre of plowing. Horsepower hours per acre were lower when the ratio of power to size of implement was lower, but increased rapidly as the combination of power and implement became less favorable. The range was from 16 to 34 horsepower hours per acre. In plowing stubble or row-crop land, a slightly higher speed was maintained and this, together with a lighter load, resulted in an average energy consumption for this operation of about 17 horsepower hours per acre.

Horses were used more frequently for light operations or when pressure of other work was less urgent and a slow speed

and careful work were wanted for good performance. For heavy work, one horse-hour was equivalent to 1.3 to 1.5 horsepower hours on the basis of work accomplished. For light work, one horse-hour was equivalent to 2.0 to 2.8 horsepower hours. Therefore, in comparison with mechanical power, horses had a considerable advantage in light work and so were more difficult to displace.

Total horsepower hours per acre of a given crop is influenced by the place it occupies in the rotation and by the kind and frequency of individual operations that are necessary. Grain crops required a relatively small number of horsepower hours, particularly if grown after a row crop. If grown after another grain crop, the necessity of plowing the land increased the consumption of energy. Row crops, particularly potatoes, required a relatively large amount of power for preparation of the land and for cultivating operations. These crops generally followed alfalfa, and involved heavy work for plowing. No conclusive evidence was found that the amount of work done or the horsepower hours used per acre varied by size of farm.

Of the total horsepower hours used in field work, about 48 percent was spent in preparation of land; somewhat more than 6 percent in planting operations, approximately 19 percent in cultivating, and 27 percent in harvesting. Of the total work done by tractors, almost 60 percent was for work in preparing the land. Horses were used for all of the principal types of work, but harvesting of forage crops was the outstanding operation. They contributed 35 percent of the total work done on fields, as measured in equivalent horsepower hours.

Considering all work done by tractors and horses on farms, it was found that on the average total consumption of energy per farm increased by 775 horsepower hours for each 10 acres of cropland on cash-crop farms, and by 865 horsepower hours for each 10 acres on mixed cash-crop-livestock farms.

In planning the type and size of power to be employed on irrigated farms, total work as well as its seasonal distribution must be considered. Total consumption of energy per farm, or total horsepower hours used, depends upon the crops grown, sizes of fields, and horsepower hours per acre for the individual operations. Seasonal distribution of energy consumption depends upon the most



opportune time for each operation, the amount of work, and the time available to do it. An illustration of the seasonal distribution on a typical cash-crop farm in the Upper Snake River Valley shows that the major power load occurs in the spring when work in preparing the land in various fields is done almost simultaneously with the planting. These are followed immediately by the cultivating operations. Harvest begins with the first cutting of alfalfa at the end of June and ends about the first week in November with the harvest of sugar beets.

Investment and operating costs were calculated for purposes of comparison--they are no longer an indication of existing levels. Operating costs of tractors per unit of work accomplished were only slightly higher than those for horses. If labor as well as power operating costs are considered, the use of tractors was considerably more economical than using horses.

In any study of the use of power on farms, the use of labor is important. A reduction in man labor and its costs is the chief purpose of using mechanical power and equipment.

Taking the average of all farms, only about 25 to 30 percent of the total labor was used in operation of power and equipment. For operation of tractors and equipment, man-hours used per farm averaged 478 while for the operation of horses and equipment man-hours used averaged 991. An additional 85 man-hours per farm were used for hired field operations. Labor used for operating power in production of major crops varied from about 4 man-hours per acre for alfalfa on which two cuttings were made to more than 14 man-hours per acre of potatoes. A considerable variation in the amount of labor used per farm in operation of power and equipment was due to the varying proportions of work done by horses and by tractors on individual farms or fields.

## FARMING IN THE MAJOR IRRIGATED AREAS OF SOUTHERN IDAHO

The major irrigated areas of southern Idaho are located along the Snake River which, together with its tributaries, provides the water needed to carry on more intensive types of agriculture than soil and climate would otherwise permit. The location of survey areas and farms visited for basic data used in this study are shown in figure 1.

Except for wheat and other small grains, the climate in southern Idaho does not permit the production of most cultivated crops without irrigation. Average annual rainfall is generally below 12 inches and seldom exceeds 4 inches during the growing season. The length of the growing season is governed primarily by elevation, which is highest in the eastern part. Because of low rainfall, there is little weather interference in field work; when it occurs, it is usually of short duration. The major meteorological data affecting farming and the use of power in field work are given in table 1 for the weather stations within the three major irrigated areas.

Crop and livestock production are typical of many of the irrigated areas in the West. Of the total land in farms included in the study, about 38 percent was in forage crops for hay, seed, or pastures; almost 30 percent was in row crops; and 20 percent was in grain crops. The remaining 14 percent of the land was in farmsteads, gardens, ditches, and wasteland, and to a minor extent, in specialty crops such as vegetable seeds and orchards. Dairying was the main livestock enterprise, although in areas located at greater distances from population centers, it was exceeded by sheep. Beef cattle were kept on a number of irrigated farms. Hog production was small on most farms and production of poultry was insignificant.

Size of power and extent of use are influenced by size of farm, type of production, and somewhat by rotation or amount of work that must go into preparing the land. A crop which was preceded by a sod or grain crop ordinarily required more work in the preparation of land than one preceded by a row crop. The type of preceding crops indicates that the usual sequence in a rotation of crops on irrigated land was a sod crop, such as alfalfa, followed by potatoes or other row crops, particularly sugar beets or beans, which in turn were followed by small grains.

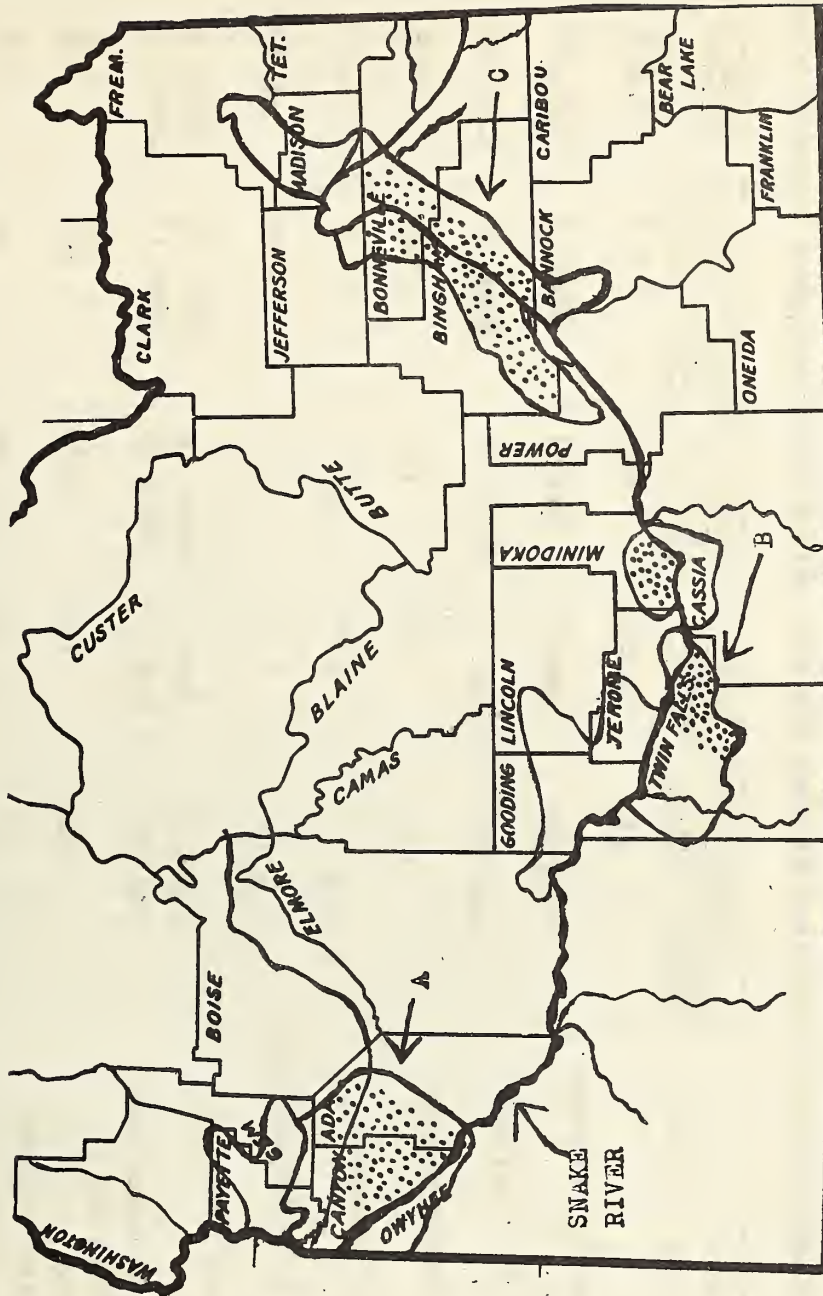


Figure 1.--Irrigated areas: Dots indicate the approximate location of farms surveyed in (A) Boise-Caldwell, (B) Twin Falls-Minidoka, and (C) Upper Snake River areas



Table 1.- Meteorological data for selected weather stations within major irrigated areas of southern Idaho

| Item   | Upper Snake River |          | Twin Falls-Minidoka |            | Boise-Caldwell |          |
|--|-------------------|----------|---------------------|------------|----------------|----------|
|  | Idaho Falls       | Aberdeen | Rupert              | Twin Falls | Boise          | Caldwell |
| Elevation, feet . . . . .  | 4,744             | 4,400    | 4,204               | 3,770      | 2,858          | 2,372    |
| Last killing frost, spring, average date . . . . .                 | May 18            | May 18   | May 12              | May 12     | Apr. 30        | Apr. 30  |
| First killing frost, fall, average date . . . . .                  | Sept. 30          | Sept. 30 | Sept. 30            | Sept. 30   | Oct. 15        | Oct. 15  |
| Average length of growing season, days . . . . .                   | 135               | 135      | 140                 | 140        | 165            | 165      |
| Average annual precipitation, inches . . . . .                     | 11.7"             | 8.8"     | 10.0"               | 9.8"       | 13.1"          | 10.1"    |
| Precipitation during growing season, inches . . . . .              | 4.5"              | 3.5"     | 3.4"                | 2.8"       | 3.3"           | 2.7"     |
| Beginning of field work, average date . . . . .                    | Apr. 1            | Apr. 1   | Mar. 16             | Mar. 16    | Mar. 1         | Mar. 1   |
| Ending of field work, average date . . . . .                       | Oct. 31           | Oct. 31  | Nov. 15             | Nov. 15    | Nov. 30        | Nov. 30  |
| Average number of clear days during season, days . . . . .         | 92                | 122      | 158                 | 123        | 112            | 131      |
| Average number of partly cloudy days during season, days . . . . . | 73                | 67       | 44                  | 90         | 78             | 68       |
| Estimated days permitting field work, days . . . . .               | 165               | 189      | 202                 | 213        | 190            | 199      |

## METHOD OF ANALYSIS

In studying the use of various types of power<sup>2/</sup> on irrigated farms of family size, major emphasis was placed upon the use of tractors and horses for field work. Field work constitutes the greater portion of the requirements for power and determines the size of unit to be employed. Belt work and hauling require considerably less power but where this kind of work is important, electric motors and trucks are used in addition to tractors and horses.

In most studies of power on farms, the measure of use for tractors and horses has been one giving time of use--tractor hours or horse-hours. For tractors, an average horsepower rating or the size expressed by the number of plow bottoms pulled is usually given. But there is a considerable difference in actual consumption of energy<sup>3/</sup> of a given tractor per hour for different operations. In plowing, the tractor is usually loaded fairly near its full capacity, whereas in harrowing or drilling the load ordinarily is not heavy enough to utilize fully the available power. When the load is light, the inefficiencies

<sup>2/</sup> The word "power" in technical terminology refers to the time rate of doing work. In more common terminology, "power" is any form of energy available for doing work, or a machine by which a specific energy is applied. Thus, one speaks of steam power, electric power, tractor power, animal power, etc. The latter terms are used frequently where work done by machines or animals is distinguished from work done by hand.

<sup>3/</sup> "Energy" is defined as the capacity for performing work. In the strictest sense of the word, it cannot be "consumed". But energy available from various sources through conversion and use is no longer available and therefore is consumed for all practicable purposes. Energy as applied by means of an internal combustion engine, such as a tractor, is measured in horsepower hours. The term "energy consumption" as used in this report, refers to the actual consumptive use of energy contained in tractor fuels. It is not limited to energy consumed for useful work but includes that used due to avoidable and unavoidable inefficiencies in the operation of tractor power on farms, such as energy consumed in idling, turning at the end of fields, and poor condition of motor or poor carburetor setting. Thus, it is not to be confused with energy requirements for specific jobs, as discussed later. (See pages 65 ff.)

in operation can sometimes be overcome by increased speed. But in most cases tractors, from the viewpoint of quality of work, are operated at the optimum speed for the particular field operation. Thus, lower investment costs for small implements are partly offset by higher operating costs of the power unit--a relationship which cannot be clarified when the use of power is expressed merely by the time of use.

Standard horsepower hours have been used in some studies to measure energy inputs.<sup>4/</sup> These were averages obtained for each individual operation on the basis of results of field tests. Although this overcomes some of the objections to the use of tractor-hours, it does not eliminate some very significant ones, such as differences in efficiency of operation due to poor adjustments of the power unit, or to improper combination of power and implement. On very few farms are operations performed in the way they are done by qualified personnel in field tests. Animal power, because of greater divisibility, can be better adjusted to individual conditions and operations than can tractor power. However, more energy is usually consumed in one horse-hour of plowing than in one horse-hour of drilling grain or mowing hay.

The purpose of this study of the use of power on farms is to learn the actual consumption of energy as it is, not as it should be. To do this, a more precise measure than tractor-hours or standard horsepower hours is needed. The ideal situation would be to measure energy consumption per acre for each field operation by means of a dynamometer. As it is practically impossible to do this for all farms to be studied and for all farm operations, fuel consumption and the efficiency of the particular power unit in converting fuel into usable energy under average farm conditions are the best available substitutes in determination of energy consumption.

If only tractors of a given type and size, using one specific type of fuel, were in use on farms, and no horses were employed, the conversion of fuel consumption into energy consumption expressed in horsepower hours would not be necessary. Instead of being expressed in horsepower hours, the use of tractors could be stated in

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<sup>4/</sup> Goodsell, Wylie D. Cost and Utilization of Power and Labor on Iowa Farms. Iowa Agr. Expt. Sta. Res. Bul. 258; 321-363, illus. 1939.



gallons of fuel consumed, as fuel consumption increases and decreases to some extent with the load. But not only does fuel consumption vary by size and type of tractor, but energy output in horsepower hours per gallon of fuel varies also. Furthermore, some tractors use gasoline, others use distillate or diesel fuels. For example, in tests made at the Nebraska Agricultural Experiment Station, six tractors using gasoline as fuel were tested with steel wheels and lugs and again with rubber-tired wheels. These tests showed that energy output per gallon of fuel at the drawbar was on the average 25 percent higher on rubber tires than on steel wheels. The difference was even greater for five tractors tested with different wheel equipment using distillate. Similarly, energy output per gallon of fuel by seven tractors operated on rubber tires was higher using gasoline than using distillate. These are average variations in test results of a number of tractors; variations between individual tractors are considerably greater.

Fuels used in the operation of tractors contain a certain amount of heat units (BTU) which, by means of an internal combustion engine, are converted to useful work. All of the useful energy released is available at the belt pulley. Energy available at the drawbar is less than that at the belt because a certain amount is required to overcome the resistance against the forward movement of the power unit itself.

Horsepower hours released per gallon of a specific type of fuel at the belt and the drawbar have been measured in a number of tests on new tractors by the Agricultural Engineering Department of the Nebraska Agricultural Experiment Station.<sup>5/</sup> Adjusting the results of these tests to farm conditions provides a means by which energy consumption can be learned for each farm operation and for a farm of a given organization from the amount of fuel consumed in a given tractor unit. Inefficiencies in the operation of a power unit, such as inadequate adjustments or an inefficient combination of power and implement, will result in comparatively high consumption of fuel and consequently in high consumption of energy. It should be emphasized that the aim of this study is to determine as accurately as possible

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<sup>5/</sup> Test results are published periodically in bulletin form by the Nebraska Agricultural Experiment Station. For explanation of method of testing and types of tests, see Nebraska Tractor Tests--1920-1948, Neb. Agr. Expt. Sta. Bul. 392, 51 pp., illus., 1949.

- the amount of energy or horsepower hours used, expended, or consumed, in farm operations.

As employed in this report, energy required in contrast to energy used, means the amount of energy that is actually required for a given field operation. This can be determined only by dynamometer tests. In the determination of energy requirement for plowing, for example, it is immaterial whether the plow is pulled by a tractor, by horses, or by hand; the energy requirements remain the same. Energy used, on the other hand, is affected by the type of power unit, the source of energy, and other factors.<sup>6/</sup>

For horse work there is no measure of input to ascertain the amount of energy made available, whether used or not. Neither is it possible to add horsepower hours of tractors to horse-hours of horses in order to obtain total use of power per acre. To overcome this difficulty, an average conversion rate for converting horse-hours into equivalent horsepower hours was ascertained from a large number of records for each operation performed by horses. This makes it possible to combine tractor and horse work, and to ascertain the total amount of energy used and the proportion of work done by each power source. Thus, all data of the use of power on farms are expressed in horsepower hours, although some of the older measures such as tractor-hours and horse-hours are also given to make comparisons possible or to point out relationships.

#### Definition of Horsepower Hour

The use of the term "belt" or "drawbar" horsepower hour is not sufficiently common for its general understanding to be assumed. It would be natural to assume that a tractor with a rating of 10 horsepower at the drawbar (DBHP), if used for 1 hour, would develop 10 drawbar horsepower hours. This is not necessarily the case. Actually, such a tractor may have a power

<sup>6/</sup> For further discussion of the relation between consumption of energy and requirement of energy and the advantages of the approach used in this study, see the chapter beginning on page 65.

output at the drawbar that varies from considerably below 10 drawbar horsepower when traveling without any load or with a light load to 10 drawbar horsepower and over, when operated with a heavy load. The amount of fuel consumed or the energy made available, within the over-all capacity of the power unit employed, depends primarily upon the amount of pull required to move the implement and the speed with which it is moved or, in other words, upon the load and the speed of operation. On farms, tractors are seldom loaded to capacity. This is true partly because a certain amount of reserve power is necessary to cope with unfavorable conditions that occur more or less frequently, and partly because farmers cannot afford to buy for each operation the particular size of implement which, under their conditions, will give the tractor the proper load. Aside from an adequate load for the tractor, farmers must consider the purchase price of the equipment and its annual use. Thus, as the load given a tractor on farms is generally lighter, the amount of power developed is less than that under test conditions.

Horsepower is a term used to define the rate of doing work. One horsepower is equal to the lifting of 33,000 pounds one foot in one minute, or 550 pounds one foot in one second. Horsepower hour is a term used to define the amount of work. One horsepower hour is equal to 1,980,000 ft./lbs. In other words, one horsepower in operation for 1 hour, 10 horsepower in operation for 6 minutes, or a 150 lb. load being moved 2-1/2 miles each are equal to one horsepower hour.

The amount of energy consumed or the fuel needed to perform work depends partly upon the efficiency of the unit to convert fuel into horsepower hours and to make them available at the drawbar, and partly upon the load the power unit is required to pull at a given speed. The efficiency of modern tractors to convert a specific type of fuel into horsepower hours and make them available at the drawbar or pulley does not vary much between the same types and sizes of tractors so long as the motors are in proper adjustment. Under field conditions it lies between 6 and about 7.5 drawbar horsepower hours per gallon of ordinary gasoline. Consumption of fuel varies, generally speaking, with the load the tractor is required to pull. However, while fuel consumption declines with a reduction in load, it cannot be reduced in direct proportion to the load. Thus, tractors are less efficient in fuel consumption for light than for heavy loads.



To illustrate differences in fuel consumption and horsepower hours per acre between major field operations performed by tractors, averages for operations most frequently performed are given in table 2. The average rating of tractors and the average size of implements used include a variety of types and sizes of power as well as different combinations of power and implement. Furthermore, average consumption of fuel in gallons consists of different types of fuel.

Horsepower hours per acre follow fuel consumption except for the differences in output per gallon of fuel, which are due to different types of fuel as well as to type, size, and condition of power unit. Between individual operations the differences in fuel consumption and horsepower hours per acre are large. They are caused primarily by differences in load. In the samples shown in table 2, they range from 0.4 gallons of fuel and 2.4 horsepower hours per acre for spiketooth harrowing to 3.3 gallons of fuel and 21.7 horsepower hours per acre for plowing sod.

Calculating energy consumption per hour of use of the tractor (in other words, horsepower hours per hour, or horsepower developed) as based upon fuel consumption, it is possible to indicate to what extent the capacity of the power unit is utilized in the various field operations. In plowing sod, an important operation so far as frequency and load are concerned, average horsepower developed on the basis of fuel consumption was about 72 percent of the average horsepower rating of the tractors used. The other extreme is illustrated by binding grain, which represents a light load for the tractor and usually involves frequent stops. In this operation, average horsepower developed from fuel was only 35 percent of the rated drawbar capacity of the tractor used.

#### Determination of the Amount of Mechanical Power Used

This determination was made possible by data available from the tractor tests in Nebraska and an accurate description of the power units available on farms, which included information relating to type of fuel used, consumption of fuel, and acres covered per day.<sup>7/</sup> Certain adjustments in the Nebraska test data were necessary, partly

<sup>7/</sup> For further discussion of the method of analysis used, see H. H. Stippler, A Method of Approach to Farm Power Studies. Agr. Engin. 25 (7) July 1944.

Table 2. - Average fuel consumption and horsepower hours for major field operations,  
three major irrigated areas, southern Idaho, 1940

| Operation                                   | Number<br>of<br>cases | Average<br>rating<br>of<br>tractor | Average<br>width<br>of<br>implement | Average |        | Average     |          |
|---|-----------------------|------------------------------------|-------------------------------------|---------|--------|-------------|----------|
|   |                       |                                    |                                     | Fuel    | Energy | consumption | per hour |
|   |                       |                                    |                                     |         |        |             |          |
|   | Number                | DBHP                               |                                     | Gal.    | HP hr. | Gal.        | HP hr.   |
| Plowing, sod or alfalfa . . . . .           | 232:                  | 14.19 :                            | 20 inch :                           | 3.3 :   | 21.7 : | 1.7 :       | 10.16    |
| Plowing, row-crop land or stubble . . . . . | 252:                  | 14.33 :                            | 20 inch :                           | 2.6 :   | 16.6 : | 1.5 :       | 9.71     |
| Discing, tandem . . . . .                   | 161:                  | 13.58 :                            | 7 foot :                            | .8 :    | 5.1 :  | 1.6 :       | 9.38     |
| Harrowing, spiketooth . . . . .             | 176:                  | 13.59 :                            | 3 section :                         | .4 :    | 2.4 :  | 1.4 :       | 8.72     |
| Leveling . . . . .                          | 176:                  | 13.90 :                            | 10 foot :                           | .7 :    | 4.3 :  | 1.4 :       | 9.31     |
| Drilling grain . . . . .                    | 94:                   | 12.98 :                            | 7.7 foot :                          | .7 :    | 4.2 :  | 1.1 :       | 6.98     |
| Planting potatoes . . . . .                 | 87:                   | 13.79 :                            | 1.9 row :                           | 1.2 :   | 8.0 :  | .8 :        | 5.10     |
| Planting beets . . . . .                    | 29:                   | 12.08 :                            | 4 row :                             | .7 :    | 4.3 :  | .8 :        | 5.10     |
| Cultivating potatoes . . . . .              | 108:                  | 13.48 :                            | 1.9 row :                           | .8 :    | 5.6 :  | 1.1 :       | 8.68     |
| Cultivating beets . . . . .                 | 64:                   | 12.06 :                            | 4.1 row :                           | .7 :    | 4.8 :  | 1.2 :       | 7.85     |
| Mowing hay . . . . .                        | 173:                  | 13.63 :                            | 6.6 foot :                          | .7 :    | 4.4 :  | 1.3 :       | 8.40     |
| Binding grain . . . . .                     | 69:                   | 14.10 :                            | 6.6 foot :                          | 1.0 :   | 6.3 :  | .8 :        | 4.97     |
| Digging potatoes . . . . .                  | 126:                  | 14.26 :                            | 1 row :                             | 2.6 :   | 17.1 : | 1.0 :       | 6.50     |
| Lifting beets . . . . .                     | 23:                   | 11.90 :                            | 1.4 row :                           | 2.2 :   | 14.3 : | 1.2 :       | 7.37     |
|   | :                     | :                                  | :                                   | :       | :      | :           | :        |

to take account of the fact that tractors are not used on farms under conditions such as are obtained during relatively short tests when load and other factors are accurately controlled, and partly because farmers frequently used tractors with different types of fuel or with different types of traction devices than those used in tests. Therefore, horsepower hours per gallon of fuel under farm conditions are lower than they are under test conditions.

Drawbar tests of tractors have been made at rated load only.<sup>8/</sup> Tractors on farms, however, are seldom operated continuously at this load. In such heavy farm work as plowing, for instance, the idling of the tractor, the turning at the end of the field, and the variation in the load even at a steady rate of work, cause a lower output of horsepower hours per gallon of fuel than is obtained in rated load tests. In other words, the efficiency of the motor to convert fuel into useful energy is reduced. The extent of reduction is difficult to ascertain because of the variety of farm conditions under which tractors operate. On the other hand, it appears desirable that an adjustment of test results to approach farm conditions be applied uniformly to all tractors in use.

Farm use of tractors consists of work of greatly varying loads, each of different duration. To adjust results of drawbar tests to such conditions, it appears that at least an adjustment to a "varying load" level at the drawbar equal to that in belt tests should be made. Belt tests of tractors include both rated load and varying load tests in which horsepower hours per gallon and consumption of fuel in gallons per hour are determined. When average values from the varying load test on the belt are used, the reduction in horsepower hours per gallon is from 15 to 25 percent below values for the rated load test.<sup>9/</sup> If the reduction found in belt tests for each individual tractor are applied to results of the rated load test at the drawbar, an adjustment to varying load conditions at the drawbar is obtained. This adjustment accounts for differences in engine performance only. It does not consider variations in efficiency of transmission and traction, which are assumed to be negligible for all practicable purposes.

<sup>8/</sup> For test data on tractors found in southern Idaho, see table 30, page 101.

<sup>9/</sup> In the varying load test on the belt the engine is operated from no load to maximum load. In the official Nebraska Tractor Test Reports, the last line of data in the varying load test gives average results of the six trials which include no load, 1/4 load, 1/2 load, 3/4 load, and maximum load.



Further adjustments in test results are frequently needed because farmers use different wheel equipment or fuel than that with which the particular tractor was tested. In these cases the amount of adjustment was approximated by the average difference in test results of all tractors for which the same tests had been made with different types of traction or fuel.

Examples of adjustments in test results to farm conditions are given in table 3 for three tractors. Drawbar test results were adjusted to a "varying load" level at the drawbar for all three tractors. This gave output of energy in horsepower hours per gallon and consumption of fuel in gallons per hour under farm use conditions which is shown at the bottom of the column headed "Selected test data." In addition, test results of each of the tractors were adjusted for different traction devices or different fuel used. Tractor A was tested with tires but found to be in use on some farms with steel wheels and spades. Tractor B was tested with spades but was in use on farms with tires. In these cases, results of belt tests are not affected by the change in traction. The change from tires to spade, as illustrated by tractor A, caused a reduction in horsepower hours per gallon at the drawbar to 76.5 percent of that obtained in the drawbar test and an increase of 9.2 percent in fuel consumption. This is the average difference for all tractors operated with distillate which were tested with both tires and spade. Similarly, to adjust for a change from spade to tires for a tractor using gasoline, as illustrated by tractor B, energy output in horsepower hours per gallon was increased by 25.9 percent, and fuel consumption reduced to 95.4 percent of that obtained in tests.

Tractor C in table 3 illustrates adjustments for a different type of fuel than that with which the tractor was tested. In this case, both belt and drawbar test results must be adjusted. Horsepower hours per gallon developed at the drawbar of all tractors tested with both gasoline and distillate, showed a reduction of 1.2 percent, distillate compared with gasoline, and a reduction of about 10 percent in consumption of fuel.

Every farm record was provided with a sheet showing the calculations of tractor power used in each farm operation. This sheet was headed by specifications of the particular power unit and the applicable test data as adjusted. It listed for each operation sizes of implements, hours of field work, acres

Table 3. - Nebraska tractor test data and adjustments to farm conditions

| Item   | Tractor A                |                                    |                          | Tractor B                          |                          |                                    | Tractor C                |                                    |  |
|--|--------------------------|------------------------------------|--------------------------|------------------------------------|--------------------------|------------------------------------|--------------------------|------------------------------------|--|
|  | Selected<br>test<br>data | Adjust-<br>ment<br>for<br>traction | Selected<br>test<br>data | Adjust-<br>ment<br>for<br>traction | Selected<br>test<br>data | Adjust-<br>ment<br>for<br>traction | Selected<br>test<br>data | Adjust-<br>ment<br>for<br>traction |  |
| Specifications   |                          |                                    |                          |                                    |                          |                                    |                          |                                    |  |
| Type of tractor . . . . .                              | Tricycle                 | Same                               | Standard                 | Same                               | Tracklayer               | Same                               |                          |                                    |  |
| Type of traction . . . . .                             | Tires                    | Spade                              | Spade                    | Tires                              | Cleats                   | Same                               |                          |                                    |  |
| Type of fuel . . . . .                                 | Dist.                    | Same                               | Gas.                     | Same                               | Gas.                     | Dist.                              |                          |                                    |  |
| Rating <sup>2</sup> , Drawbar HP . . . . .             | 20                       | Same                               | 16                       | Same                               | 18                       | 16                                 |                          |                                    |  |
| Belt HP. . . . .                                       | 26                       | Same                               | 25                       | Same                               | 24                       | 22                                 |                          |                                    |  |
| Belt tests   |                          |                                    |                          |                                    |                          |                                    |                          |                                    |  |
| Horsepower hours per gallon                            |                          |                                    |                          |                                    |                          |                                    |                          |                                    |  |
| Test D, Rated load . . . . .                           | 11.00                    | Same                               | 10.54                    | Same                               | 7.89                     | 7.88                               |                          |                                    |  |
| Test E, Varying load . . . . .                         | 9.11                     | Same                               | 8.21                     | Same                               | 6.67                     | 6.65                               |                          |                                    |  |
| Test E in percent of Test D . . . . .                  | 83                       | Same                               | 78                       | Same                               | 84                       | 84                                 |                          |                                    |  |
| Gallons per hour                                       |                          |                                    |                          |                                    |                          |                                    |                          |                                    |  |
| Test D, Rated load . . . . .                           | 2.397                    | Same                               | 2.385                    | Same                               | 3.072                    | 2.703                              |                          |                                    |  |
| Test E, Varying load . . . . .                         | 1.791                    | Same                               | 1.807                    | Same                               | 2.283                    | 2.036                              |                          |                                    |  |
| Test E in percent of Test D . . . . .                  | 75                       | Same                               | 76                       | Same                               | 74                       | 75                                 |                          |                                    |  |
| Drawbar tests  |                          |                                    |                          |                                    |                          |                                    |                          |                                    |  |
| Test H, Rated load                                     |                          |                                    |                          |                                    |                          |                                    |                          |                                    |  |
| Horsepower hours per gallon . . . . .                  | 9.57                     | 7.32                               | 6.92                     | 8.71                               | 6.35                     | 6.27                               |                          |                                    |  |
| Gallons per hour. . . . .                              | 2.140                    | 2.337                              | 2.299                    | 2.193                              | 2.949                    | 2.657                              |                          |                                    |  |
| Test H, Adjusted to "varying load" level<br>(farm use) |                          |                                    |                          |                                    |                          |                                    |                          |                                    |  |
| Horsepower hours per gallon . . . . .                  | 7.92                     | 6.06                               | 5.39                     | 6.79                               | 5.37                     | 5.29                               |                          |                                    |  |
| Gallons per hour . . . . .                             | 1.599                    | 1.746                              | 1.7433                   | 1.662                              | 2.191                    | 2.001                              |                          |                                    |  |

<sup>1</sup>/ From test results as published by the Dept. of Agr. Engin., Nebr. Agr. Expt. Sta. For method of testing see Nebraska Tractor Tests -- 1920-1948. January 1949. Expt. Sta. Bul. 392. <sup>2</sup>/ Rounded to nearest full horsepower.

covered, fuel consumption, and adjusted horsepower hours per gallon. An example of this record sheet is given in table 31, page 102. Check data which included calculated acres per day and time of operation, as calculated from fuel consumption under varying and rated load conditions at the drawbar, were omitted from this table. It is pointed out again that actual fuel consumption as reported by the farmer was converted into energy consumption expressed in horsepower hours. Thus, higher consumption of fuel on farms than is found in tests, which is due to the combined effects of age, stage of repair and upkeep, excessive idling, and other factors, is considered. This results in data showing consumption of energy as it was reported, not necessarily as it should be.

#### Determination of Amount of Animal Power Used

This determination and conversion of horse-hours into horsepower hours is hindered by the fact that records were obtained only on farms where tractors were in use. On these farms horses for some jobs are seldom used, and the number of cases in which horses are employed for a specific type of work are relatively small.

Average rates of performance of horses for individual field operations, as obtained in this study, were compared with average rates of horse work in other studies within the same general area and certain adjustments were made when the sample obtained in the study was too small to be representative. By comparing rates of tractor work with those of horse work, conversion factors were calculated for each individual operation for which horses were employed. Using these factors, horse hours reported for each operation were converted into equivalent horsepower hours.

This conversion of animal power into mechanical power permits the expression of total energy consumption per acre of specific crops and total power use on farms by means of a common denominator regardless of the type of power actually employed.



## POWER RESOURCES ON FARMS

### Tractors

The choice of types and sizes of tractors employed on farms is determined chiefly by the type of crops grown and the size of operations. However, other considerations, and particularly local repair facilities, ease of operation, especially ease with which various implements or tools can be changed, and salesmanship of local dealers, influence considerably the type of power used. The predominance of certain makes of tractors on farms in particular areas of southern Idaho indicated that certain manufacturers were especially well represented, not only with effective local sales departments, but also with the facilities for service and repair to back them up.

Classification of tractors according to type of chassis into standard, tricycle, and crawler or tracklayer-type tractors appeared to have less significance than in earlier years. Modern standard or four-wheel tractors had wheels adjustable to the width of rows, and even crawler tractors have been adapted to row-crop cultivation. Furthermore, some wheel tractors are supplied with different front wheel assembly either as so-called tricycle or general-purpose tractors or as standard four-wheel-type tractors, whichever is preferred. Even the classification of tractors as to type of driving wheels, whether rubber-tired or equipped with steel wheels and lugs, and whether operated with gasoline or distillate, was less significant than formerly, as a change-over from steel to rubber or gasoline to distillate is relatively easy. On the other hand, a classification of farm power according to size expressed in drawbar horsepower rating and the measurement of energy consumption in horsepower hours, became more significant.

Of the 296 tractors employed on the farms, 70 percent were tricycle-type tractors, 27 percent standard tractors, and 3 percent tracklayers. The average age in 1940 varied from 4.6 years for tricycle to 5.2 years for standard and 6.3 years for crawler tractors. About one-fourth of the tricycle and standard tractors and 30 percent of the tracklayers were bought second-hand. The average drawbar horsepower rating was almost the same for the 2-wheel-type classifications; tracklayers had about 12 percent more power. Because of the rather slight variation in the average rating, the proportions of total power available from different types of tractors were nearly the same as those given for the number of tractors.

More than three-fourths of all wheel tractors were operated on rubber tires and the average age of these was considerably lower than that of tractors operated on steel wheels. Less than half of the latter were purchased new, while almost 80 percent of the rubber-tired tractors were purchased new. The average rating of wheel tractors operated on steel wheels was 11 percent higher than that of rubber-tired tractors. No diesel tractors were found on the farms surveyed, but about 22 percent of all tractors were operated with distillate as fuel. The age of these tractors was slightly higher than the age of those using gasoline. A third of those operated with distillate were bought second-hand, as compared with about 20 percent of those operated with gasoline. Tractors operated with distillate averaged slightly lower in power than those using gasoline. More than 90 percent of all tractors had a rating of less than 20 drawbar horsepower and 58 percent had less than 15.

### Horses

Almost a third of the total power available for field work on irrigated farms having tractors in southern Idaho in 1940 consisted of animal power.<sup>10/</sup> This indicates that farmers using tractors relied considerably upon horses to do farm work.

The number of horses and the use of this type of power varied by different types and sizes of farms as well as by major areas. A smaller proportion of the specialized livestock farms using tractors also kept horses than was true for the other major types of farms. Furthermore, for this type of farm, the average number of horses per farm was smaller. These farms also made the least use of horses, using them more for other farm work than for field operations. Timeliness of operation and performance of field work in addition to the care of livestock, combined frequently with a relatively small labor force, made it necessary to do most of the field work quickly.

A larger percentage of specialized cash-crop farms kept horses and they were used more extensively than on specialized livestock farms. Horses were also used more for field

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<sup>10/</sup> The terms "animal power" or "horses" are used to include work horses and mules. Only horses or mules used for farm work were considered as available power. Colts and saddle horses not used for farm work were not included in these discussions.

operations than for other farm work. On mixed cash-crop-livestock farms, the largest number of work horses were kept per farm, while the average size of the tractors per farm was the lowest, and greater total use was made of animal power. Use of horses for field work in percentage of total horse work was somewhat lower than on cash-crop farms. This indicates a greater need for animal power in connection with livestock production. Field work by horses was of a different type than on cash-crop farms because of the larger production of feed crops. For each type of farm, the number of work horses per farm as well as their use increased with the size of farm.

The number of horses per farm, combined with the kind of use that was made of them in relation to the consumption of energy which tractors would have for the same kind of work, was used to evaluate available animal power in terms of equivalent mechanical power. On this basis, horses provided a larger part of the available power on mixed cash-crop-livestock farms than on other types. Approximately 33 percent of the power available for use in field work was available as animal power on mixed farms, 29 percent on cash-crop farms, and 26 percent on specialized livestock farms. The percentage which animal power constituted of the total available power per farm increased progressively with the size of farm.

#### Total Power for Field Work

That the amount of power employed on farms is determined primarily by the amount of field work that must be done within rather specific time limits has been pointed out. In any one area and for one particular type of farm organization, the amount of power needed can be approximated by the number of acres under cultivation and the average acreage per drawbar horsepower.

The majority of farmers in the irrigated areas of southern Idaho, in 1940, found it advantageous to use horses in addition to tractors. Total power available for field work consisted of these two major types. Other power sources such as motor trucks and electric motors may lighten the load for tractors and horses by doing other than field work, but cannot be used for the principal farm operations. On irrigated farms in southern Idaho both the size of tractor and the number of horses increased as the size of farm increased, but the power available per acre of cultivated land on small farms was greater than on larger ones (table 4).



Table 4. - Available power for field work by size and type of farm, three major irrigated areas, southern Idaho, 1940

| Size and type of farm                     | Farms  | Average<br>culti-<br>vated<br>acres | Average<br>rating<br>of<br>tractor | Average<br>number<br>of<br>horses | Average<br>cultivated<br>acres per<br>equivalent<br>horsepower |
|---|--------|-------------------------------------|------------------------------------|-----------------------------------|--|
|   | Number | Acres                               | DBHP                               | Number                            | Acres  |
| Size of farm.                             |        |                                     |                                    |                                   |  |
| Under 50 acres . . . . .                  | 31     | 36.8                                | 12.63                              | 1.5                               | 2.34   |
| 50-74 acres . . . . .                     | 83     | 64.0                                | 13.65                              | 2.4                               | 3.44   |
| 75-99 acres . . . . .                     | 50     | 85.8                                | 14.97                              | 3.2                               | 4.00   |
| 100-124 acres . . . . .                   | 29     | 112.6                               | 15.87                              | 3.7                               | 4.85   |
| 125-149 acres . . . . .                   | 44     | 135.1                               | 15.89                              | 4.1                               | 5.62   |
| 150-199 acres . . . . .                   | 27     | 170.3                               | 18.73                              | 5.0                               | 5.95   |
| 200 acres and over . . . . .              | 13     | 238.8                               | 22.79                              | 6.3                               | 6.73   |
| Type of farm                              |        |                                     |                                    |                                   |  |
| Livestock farms . . . . .                 | 36     | 80.7                                | 16.32                              | 2.8                               | 3.64   |
| Cash-crop farms . . . . .                 | 137    | 95.7                                | 15.37                              | 3.2                               | 4.40   |
| Mixed cash-crop-livestock farms . . . . . | 104    | 111.9                               | 14.81                              | 3.6                               | 5.07   |
| All farms . . . . .                       | 277    | 99.8                                | 15.29                              | 3.3                               | 4.55   |

The percentage of total available power which consisted of horses became progressively larger as the size of farm increased. On tractor farms with less than 50 acres of cultivated land, slightly more than 20 percent of the available power was represented by horses; on farms of 200 acres and more, about 35 percent of all field power consisted of horses. On the average, of all types and sizes of farms, horses made up about 30 percent of the power available for field work. The greater proportionate use of horses on larger irrigated farms apparently indicates also that many farmers have filled their need for additional power with a more flexible source of power rather than by shifting to a larger mechanical power unit or purchase of an additional tractor.

#### Other Power on Farms

In addition to the major types of farm power--tractors and horses--which are used chiefly in field work, other types of power were found on many farms. Their use does not depend primarily upon the acreage in the farm but rather upon the distances to fields and the nearest trading center as well as upon the organization and size of the farm business as measured by the type and volume of products marketed. Trucks, automobiles for farm use, and electric motors, relieve tractors and horses of jobs in which their use would be expensive either in terms of actual costs because they are not well suited for the type of work, or by causing a neglect of the major farm work for which they are intended.

Motor Trucks. - Motor trucks were used on 45 percent of all farms (table 5). The proportion of farms having trucks and their capacity varied with size and type of farms. The proportion of farms reporting trucks increased with the size of farm. Of the farms with less than 50 acres of cultivated land, only about a fourth reported trucks, while all farms of 200 acres or over had trucks. The larger capacity of trucks on farms of larger size resulted chiefly from use of a larger truck rather than from a larger number of trucks per farm. Only two farms reported having more than one truck, and trucks of from one-half to one-and-one-half ton capacity predominated. Only nine trucks, or 7 percent of the total of all trucks, had a capacity of from 2 to 3-1/4 tons.

Table 5. - Farm trucks and automobiles used for farm business on farms, by size and type of farm, three major irrigated areas, southern Idaho, 1940

| Size and type<br>of farm                  | Farms        |        | Average: Farms using auto |        |
|---|--------------|--------|---------------------------|--------|
|   | : capacity:  |        | : for farm business       |        |
|   | : of trucks: |        | : per farm:               |        |
|   | Total        | Having | Total                     | Having |
|   | No.          | No.    | Tons                      | No.    |
| Size of farm                              |              |        |                           |        |
| Under 50 acres . . .                      | 31           | 8      | 1.1                       | 26     |
| 50-74 acres . . .                         | 83           | 32     | 1.2                       | 67     |
| 75-99 acres . . .                         | 50           | 18     | 1.2                       | 42     |
| 100-124 acres . . .                       | 29           | 13     | 1.4                       | 23     |
| 125-149 acres . . .                       | 44           | 21     | 1.4                       | 33     |
| 150-199 acres . . .                       | 27           | 20     | 1.5                       | 17     |
| 200 and over . . .                        | 13           | 13     | 1.7                       | 8      |
| Type of farm                              |              |        |                           |        |
| Livestock farms . . .                     | 36           | 9      | .9                        | 30     |
| Cash-crop farms . . .                     | 137          | 59     | 1.4                       | 104    |
| Mixed cash-crop-<br>livestock farms . . . | 104          | 57     | 1.4                       | 82     |
| All farms . . . . .                       | 277          | 125    | 1.3                       | 216    |

A higher proportion of mixed cash-crop-livestock farms had trucks than was true for specialized livestock or cash-crop farms. This relationship held for individual areas except in the Boise-Caldwell Area, where specialized cash-crop farms, frequently growing products of high perishability, used relatively more trucks than other types of farms. Specialized livestock farms, predominantly dairy farms, not only used the smallest number of trucks but also had the lowest capacity of trucks per farm.

Automobiles. - Passenger automobiles were used for farm business on 78 percent of all farms. They were used mainly for hauling small repair parts and supplies or driving to and from fields located at some distance from the farmstead. The number of farms on which automobiles were used for farm business was greater for those types for which the percentage of farms using trucks was relatively low. Thus, on livestock farms, more farms reported automobiles used for farm business



than on the other major types. For small farms, those of under 50 acres, a larger proportion (84 percent) reported use of automobiles for farm use than farms of 200 acres and over (62 percent) (table 5).

A number of farmers had changed their automobile bodies, particularly older models, by enlarging the trunk, to increase the capacity for light loads. In other cases, they used small trailers to haul supplies and farm products to and from the farm. On the other hand, a pick-up truck was often used for pleasure purposes if no family automobile was available. But even on farms on which trucks were in use, the family car was frequently used for business trips to town or to haul repair parts and light loads as well as for trips to and from fields.

Electric Power. - Electric power was available on 97 percent of all farms. The proximity to the sources of electric power, as well as relatively close settlement of irrigation projects, favored an early connection of farms to power lines. But on many farms electricity was used in the farm home only, chiefly for lighting and household appliances. Only about 60 percent of the farms connected to power lines reported electric motors used on the farm. There was little relation between size of farm and extent of use of electric motors.

A larger proportion of specialized livestock farms and mixed cash-crop-livestock farms that were wired reported the use of electric motors than did specialized cash-crop farms. These electric motors were usually small; only 25 percent of all motors used were one horsepower or over. Specialized livestock farms had the smallest number of motors of larger size. Motors were commonly used for milking machines, feed grinders, water pumps, and in repair shops (table 6).

## ENERGY CONSUMPTION ON FARMS

The use of horsepower hours in expressing tractor use and conversion of horse-hours into equivalent horsepower hours have made it possible to present the following analysis of physical input of energy on irrigated farms beginning with individual field operations, continuing with the use of power for major crops, and finally determining total horsepower hours used per farm.

Table 6. - Electricity available on farms and use of electric motors, three major irrigated areas, southern Idaho, 1940

| Size and type<br>of farm                | Farms |            |          | Electric motors |                     |
|---|-------|------------|----------|-----------------|---------------------|
|   | Total | Having     | Using    | Under<br>1 HP   | 1 HP<br>and<br>over |
|   |       | electric   | electric |                 |                     |
|   |       | connection | motors   |                 |                     |
|   | No.   | No.        | No.      | No.             | No.                 |
| Size of farm                            |       |            |          |                 |                     |
| Under 50 acres . . .                    | 31    | 31         | 16       | 32              | 9                   |
| 50-74 acres . . .                       | 83    | 81         | 47       | 68              | 22                  |
| 75-99 acres . . .                       | 50    | 47         | 32       | 32              | 10                  |
| 100-124 acres . . .                     | 29    | 27         | 17       | 17              | 11                  |
| 125-149 acres . . .                     | 44    | 43         | 24       | 23              | 6                   |
| 150-199 acres . . .                     | 27    | 26         | 15       | 17              | 6                   |
| 200 and over . . .                      | 13    | 13         | 8        | 12              | 4                   |
| Type of farm                            |       |            |          |                 |                     |
| Livestock farms . .                     | 36    | 34         | 27       | 42              | 6                   |
| Cash-crop farms . .                     | 137   | 134        | 68       | 89              | 28                  |
| Mixed cash-crop-<br>livestock farms . . | 104   | 100        | 64       | 70              | 34                  |
| All farms . . . . .                     | 277   | 268        | 159      | 201             | 68                  |

Horsepower Hours Used in Individual Field Operations  
and Rates of Performance of Tractors

The draft of an implement and the speed at which it is operated, the energy required to move the source of power, the condition and stage of adjustment of the unit, and the ability of the operator to reduce energy losses to a minimum, strongly influence the amount of energy required for certain work. The amount of fuel used, together with the efficiency of the engine in converting fuel into energy, are used to measure consumption of energy.

Energy output of tractors is expressed in horsepower hours (HP hours). The information needed to ascertain the output consists of an accurate description of the power unit in order to approximate its efficiency under farm conditions, consumption of fuel per acre or per hour, speed of operation, and acres covered per hour or per day. With these data and by adjusting results of the Nebraska tests to more nearly approach farm conditions, HP hours used per acre can be calculated.

Table 32, page 105, summarizes all tractor field operations reported by farmers in the three areas in which the study was made. In general, the acreage covered per 10-hour day in any one operation increased with the size of implements but usually not in direct proportion because speed of operation declined as size of implement increased. This is indicated by the records of plowing sod or alfalfa. A 12-HP tractor pulling a one-bottom 14-inch plow had an average rate of performance of 0.3 acres per inch of cut per day, while a 25-HP tractor pulling a three-bottom 14-inch plow had a rate of performance of 0.2 acres per inch of cut per day. In plowing row-crop land or stubble, the load was lighter and the rate of performance was about the same for small tractors pulling small plows as for large tractors pulling larger plows. Horsepower hours declined as the size of the outfit increased, but this decrease in consumption of energy was irregular.

The main field operation performed by tractors was plowing, of which some was done on almost every farm. Furthermore, on most farms plowing represented the heaviest type of work in which the load could be made to fit the size of the tractor unit better than in most other field operations.

As consumption of energy was measured by consumption of fuel and the consumption did not decline in proportion to a decrease in load, the major cause for variations in horsepower hours per acre was due to inefficient combinations of power and implements. Although a closer fit between size of power and load may be obtained for plowing than for most other farm operations, variations in load for this job still resulted from different types of soil and varying moisture content, different depth of plowing, etc. Ordinarily, farmers chose the combination of power and size of plow that will permit the performance of the work under the most difficult, rather than under average, conditions.

In table 7, horsepower hours per acre for plowing sod or alfalfa and the major related factors are listed according to combinations of size of power and size of plow; that is, according to the rated drawbar horsepower of the tractors per inch of cut of the moldboard plows. Each line represents the average of a number of different combinations of tractors, fuels, and sizes of plows. The variation in horsepower hours per acre between individual combinations was considerable for various reasons such as speed of operation and consumption of fuel per acre. These again reflected operating conditions. For instance, if the soil were heavy, or if a farmer felt that plowing at greater depth than usual were necessary for an effective job, he



Table 7.- Horsepower hours used for plowing in relation to the combination of power and implement,  
three major irrigated areas, southern Idaho, 1940

| Average rated power of tractor per<br>inch of moldboard (HP) plow | Average: Speed :Fuel con-: Acres : Horse- |    |   |      |         |      |                                     |  |                                       |  |
|---|---|----|---|------|---------|------|-------------------------------------|--|---------------------------------------|--|
|   | Cases                                     |    | : cut of : of : sumption : per 10-: power |      |         |      | : plow : opera-: per : hour : hours |  | : used : tion : hour : day : per acre |  |
|   | : Number:                                 |    | : Inches:                                 |      | : MPH : |      | : Gal. :                            |  | : Acres :                             |  |
|   |   |    |   |      |         |      |                                     |  | HP hr.                                |  |
|   |   |    |   |      |         |      |                                     |  | Plowing sod and alfalfa               |  |
| 0.459   | 19  | 27 | 2.78                                      | 1.71 | 6.2     | 16.3 |                                     |  |                                       |  |
| 0.550   | 29  | 25 | 3.13                                      | 1.83 | 6.6     | 17.4 |                                     |  |                                       |  |
| 0.628   | 66  | 20 | 2.99                                      | 1.72 | 5.1     | 20.9 |                                     |  |                                       |  |
| 0.734   | 42  | 19 | 3.04                                      | 1.81 | 5.2     | 22.8 |                                     |  |                                       |  |
| 0.819   | 26  | 17 | 3.51                                      | 1.52 | 4.9     | 22.8 |                                     |  |                                       |  |
| 0.956   | 26  | 17 | 3.58                                      | 1.92 | 5.6     | 24.0 |                                     |  |                                       |  |
| 1.029   | 12  | 16 | 3.41                                      | 1.90 | 5.6     | 25.0 |                                     |  |                                       |  |
| 1.121   | 8   | 16 | 3.55                                      | 2.14 | 5.6     | 28.0 |                                     |  |                                       |  |
| 1.234   | 2   | 16 | 3.51                                      | 2.10 | 5.2     | 27.9 |                                     |  |                                       |  |
| 1.422   | 3   | 15 | 3.77                                      | 1.16 | 4.8     | 34.4 |                                     |  |                                       |  |
| Total 0.739   | 233                                       | 20 | 3.18                                      | 1.78 | 5.5     | 21.7 |                                     |  |                                       |  |
|   |   |    |   |      |         |      |                                     |  | Plowing stubble and row-crop land     |  |
| 0.459   | 20  | 28 | 3.38                                      | 1.7  | 8.1     | 12.1 |                                     |  |                                       |  |
| 0.549   | 39  | 25 | 3.62                                      | 1.8  | 8.2     | 13.1 |                                     |  |                                       |  |
| 0.630   | 73  | 20 | 3.49                                      | 1.6  | 6.4     | 15.8 |                                     |  |                                       |  |
| 0.732   | 43  | 22 | 3.55                                      | 1.7  | 6.5     | 17.1 |                                     |  |                                       |  |
| 0.820   | 22  | 18 | 3.99                                      | 1.5  | 6.6     | 17.1 |                                     |  |                                       |  |
| 0.958   | 24  | 22 | 4.00                                      | 1.9  | 6.7     | 19.9 |                                     |  |                                       |  |
| 1.028   | 13  | 16 | 4.13                                      | 1.8  | 6.4     | 21.0 |                                     |  |                                       |  |
| 1.128   | 14  | 16 | 3.82                                      | 2.0  | 6.1     | 22.9 |                                     |  |                                       |  |
| 1.233   | 3   | 16 | 4.28                                      | 2.0  | 6.6     | 22.9 |                                     |  |                                       |  |
| 1.417   | 2   | 16 | 3.54                                      | 2.5  | 5.2     | 30.6 |                                     |  |                                       |  |
| Total 0.731   | 252                                       | 21 | 3.67                                      | 1.7  | 6.9     | 16.9 |                                     |  |                                       |  |

was not able to maintain average speed for this type of operation. His consumption of fuel would be greater than that of another farmer operating a similar outfit who did not encounter these conditions or who did not feel it necessary to plow deep.

Horsepower hours per acre of plowing sod increased as the combination of power and implement became less favorable. When less than one-half horsepower per inch of cut was used, consumption of energy averaged slightly more than 16 horsepower hours. When more than 1.4 horsepower per inch of cut was used, consumption of energy was more than twice that amount. In almost 50 percent of all cases, a combination of less than seven-tenths horsepower per inch of plow was used, and 67 percent of the cases had a combination of less than eight-tenths rated horsepower per inch of plow. Average consumption of energy for plowing sod was almost 22 horsepower hours per acre. The better combinations are obtained with larger plows; that is, the average size of plow declined as the combination became less favorable. Although the average speed of operation increased somewhat with the greater unfavorableness of combination, this increase was not sufficient to offset a smaller cut of plow, which resulted in a decrease in the amount of work per day. Figure 2 illustrates the increase in horsepower hours per acre accompanying an increase in the amount of power per inch of plow.

Results similar to those for plowing sod are found in a relationship between average horsepower hours per acre and the combination of power and implement for plowing stubble or row-crop land. A lighter load, permitting generally higher speeds, resulted in higher performance rates in terms of acres covered per 10-hour day and consequently in lower consumption of energy per acre. Horsepower hours per acre for the average of all combinations of plowing stubble was about 77 percent of the average for plowing sod. In plowing stubble the possibility of overcoming unfavorableness in combination by higher speeds was lessened, so that horsepower hours per acre for combinations of 0.9 horsepower per inch of cut and over was 84 percent of that for plowing sod. For combinations under 0.9 horsepower per inch of plow, consumption of energy for plowing stubble was 74 percent of that for plowing sod. Speed of operation in plowing stubble for combinations under 0.9 horsepower per inch of plow was 15 percent above that for plowing sod. For combinations above 0.9 horsepower, an increase in speed of only 12 percent could be attained as tractors were already operated near their limits of possible operating speed.



DBHP  
hours  
per acre

28

Plowing sod or alfalfa

26

24

22

20

18

16

.50 .60 .70 .80 .90 1.00 1.10 1.20 1.30

Group averages of rated power of tractor per inch of plow

$$y = 10.176 + 13.647 x$$

DBHP  
hours  
per acre

24

Plowing stubble or rowcrop land

22

20

18

16

14

12

.50 .60 .70 .80 .90 1.00 1.10 1.20 1.30

Group averages of rated power of tractor per inch of plow

$$y = 5.2806 + 15.631 x$$

Figure 2.- Horsepower hours per acre for plowing in relation to the combination of power and implement, three irrigated areas, southern Idaho, 1940



Rates of Performance of Horses and Equivalent  
Horsepower Hours of Mechanical Power

Rates of work of horses are generally expressed in number of horse-hours per acre. This method was followed in the study here reported only to the extent that it was needed for conversion of horse-hours into equivalent HP hours.

For many operations on tractor farms, horses were not used frequently enough so that satisfactory rates of performance could be obtained to use as the sole basis for conversion into comparable rates for mechanical power. In these cases the limited number of records of horse work were used in connection with rates obtained in earlier studies in the same general area and conversion ratios were established on a more reliable basis. In table 33, page 114, rates for work performed by horses on the farms studied are shown for operations in which the number of cases is large enough to permit satisfactory averages. These are given for each operation by size of implement and size of team used. No adjustment could be made to allow for quality of the individual team; in other words, for the weight or strength of the horses. For this reason, in some instances the average amount of work done per 10-hour day will be found greater and the average number of horse-hours per acre smaller for a 2-horse team than for a 3-horse team pulling the same size of implement.

The decision whether to use horses or tractors, assuming both were available on the same farm, was not made solely on the basis of the amount of horse-hours and HP-hours involved in the particular operation and their costs, but also on the basis of the amount of labor needed to operate the power. If family labor were used and no other farm work was urgent, labor may not have been an important factor. But in the case of hired labor and during the rush season, time involved and the amount of labor used with either source of power was significant. Use of horses generally required considerably more man labor than use of tractors for the same type of work. The proportion varied by individual operations but, in general, more labor was used in heavy field work done by horses than in comparatively light field operations. When tractors were used, man-hours per acre in many cases were less than half the man labor required with the use of horses. Furthermore, implements used with horses often required one man in addition to the teamster, whereas tractor implements are built so that the tractor driver can also control the implement from the driver's seat.

When both mechanical and animal power are available, tractors are used generally for heavy work and for speed. Horses are used for light work and during times when no other work is pressing. This does not preclude the use of tractors for light work nor does it mean that horses were idle in times of rush work.

Table 8 gives the relative importance of tractor and horse use on these 277 farms in southern Idaho. Field operations are arranged by major groups--land preparation, planting, crop cultivation, and harvesting. Consumption of energy in equivalent horsepower hours is given for both power sources combined. Furthermore, equivalent horsepower hours from tractor and horses is shown in percentage of all field work as well as in percentage of each major group of operations.

In all field operations and for all crops grown on these farms, tractors contributed less than two-thirds and horses slightly more than one-third of the horsepower hours used. The proportion of work done by horses varied greatly by individual operations. It ranged from zero for some of the heavy work to around 70 percent for cultipacking, corrugating, and haying, and 85 percent for cutting and raking beans.

Horsepower hours used, in percentage of total consumption of energy for field work, were determined by the frequency with which a given operation was performed or the number of cases, by total acreage covered during the season, and by average horsepower hours per acre. Thus, a given field operation may have a high level of energy use but may not have been performed frequently enough or on large enough fields to have been important so far as total use of energy for field work was concerned.

More than half of the total number of horsepower hours of tractors used were employed in preparing the land. Plowing sod and stubble were the most important individual operations. Disking, harrowing, and leveling were also operations for which large amounts of energy were used by tractors. Next in importance, so far as the total amount of mechanical power is concerned, were the harvesting operations. Among these, mowing alfalfa, digging potatoes, binding grain, lifting beets, and combining were the outstanding individual operations. Of the cultivating jobs, cultivating of potatoes and beets were the only major ones. Very little tractor power was used for planting operations. Of these, planting of potatoes and drilling of grain may be considered important in use of mechanical power.

Table 8.- Total equivalent horsepower hours for field operations and proportions from tractors and horses, three major irrigated areas, southern Idaho, 1940

| Field operation                               | Total amount | Equivalent horsepower hours |         |           |         | Work done with tractors |         |         |         |
|---|--------------|-----------------------------|---------|-----------|---------|-------------------------|---------|---------|---------|
|   |              | Percentage of :             |         | Amount    |         | Percentage of :         |         | All :   |         |
|   |              | Total :                     | Main :  | field :   | work :  | Total :                 | Main :  | field : | work :  |
|   |              | EHP hours                   | Percent | EHP hours | Percent | EHP hours               | Percent | Percent | Percent |
| Plowing . . . . .                             | 271,149      | 20.6                        | 42.9    | 270,490   | 99.6    | 31.7                    | 53.7    |         |         |
| Disking . . . . .                             | 107,343      | 8.2                         | 17.0    | 104,966   | 97.8    | 12.3                    | 20.9    |         |         |
| Harrowing, spiketooth . . . . .               | 129,286      | 9.8                         | 20.4    | 60,433    | 46.7    | 7.1                     | 12.0    |         |         |
| Cultipacking or rolling . . . . .             | 7,644        | .6                          | 1.2     | 2,341     | 30.6    | .3                      | .5      |         |         |
| Leveling . . . . .                            | 57,198       | 4.3                         | 9.0     | 42,168    | 73.7    | 4.9                     | 8.4     |         |         |
| Diking . . . . .                              | 5,129        | .4                          | .8      | 3,211     | 62.6    | .4                      | .6      |         |         |
| Corrugating . . . . .                         | 49,873       | 3.8                         | 7.9     | 14,989    | 30.0    | 1.8                     | 3.0     |         |         |
| Miscellaneous operations . . . . .            | 5,126        | .4                          | .8      | 4,667     | 91.0    | .5                      | .9      |         |         |
| Total land preparations . . . . .             | 633,048      | 48.1                        | 100.0   | 503,265   | 79.5    | 59.0                    | 100.0   |         |         |
| Total planting . . . . .                      | 87,092       | 6.6                         | ---     | 35,913    | 41.2    | 4.2                     | ---     |         |         |
| Total crop cultivation . . . . .              | 243,954      | 18.6                        | ---     | 146,580   | 60.1    | 17.2                    | ---     |         |         |
| Haying . . . . .                              | 194,243      | 14.8                        | 55.4    | 70,263    | 36.2    | 8.2                     | 42.1    |         |         |
| Combining . . . . .                           | 11,395       | .9                          | 3.3     | 11,395    | 100.0   | 1.3                     | 6.8     |         |         |
| Digging potatoes . . . . .                    | 65,009       | 5.0                         | 18.6    | 58,090    | 89.4    | 6.8                     | 34.8    |         |         |
| Lifting beets . . . . .                       | 37,830       | 2.9                         | 10.8    | 10,777    | 28.5    | 1.3                     | 6.5     |         |         |
| Culling and raking beans . . . . .            | 16,991       | 1.3                         | 4.8     | 2,461     | 14.5    | .3                      | 1.5     |         |         |
| Binding grain and corn . . . . .              | 21,435       | 1.6                         | 6.1     | 12,700    | 59.2    | 1.5                     | 7.6     |         |         |
| Lifting onions . . . . .                      | 1,217        | .2                          | 1.0     | 531       | 43.6    | .1                      | .5      |         |         |
| Miscellaneous harvesting operations . . . . . | 2,423        | ---                         | ---     | 647       | 26.7    | .1                      | .2      |         |         |
| Total harvesting . . . . .                    | 350,543      | 26.7                        | 100.0   | 166,864   | 47.6    | 19.6                    | 100.0   |         |         |
| Total all field operations . . . . .          | 1,314,637    | 100.0                       | ---     | 852,622   | 64.9    | 100.0                   | ---     |         |         |

(Continued)



Table 8.-- (Continued). Total equivalent horsepower hours for field operations and proportions from tractors and horses, three major irrigated areas, southern Idaho, 1940

|                                     | Field operation | Total amount | Equivalent horsepower hours |           |           |           | Work done with horses |           |           |           |
|-------------------------------------|-----------------|--------------|-----------------------------|-----------|-----------|-----------|-----------------------|-----------|-----------|-----------|
|                                     |                 |              | Percentage of :             |           | Amount    |           | Percentage of :       |           | All :     |           |
|                                     |                 |              | All :                       | Main :    | field :   | group :   | All :                 | Main :    | field :   | group :   |
|                                     |                 |              | work :                      |           | work :    |           | work :                |           | work :    |           |
|                                     |                 |              | Percent :                   | Percent : | Percent : | Percent : | Percent :             | Percent : | Percent : | Percent : |
|                                     |                 |              | EHP hours                   |           |           |           |                       |           |           |           |
| Plowing                             | .....           | 271,449      | 20.6                        | 42.9      | 959       | .4        | .2                    | .7        |           |           |
| Disking                             | .....           | 107,343      | 8.2                         | 17.0      | 2,377     | 2.2       | .5                    | 1.8       |           |           |
| Harrowing, spiketooth               | .....           | 129,286      | 9.8                         | 20.4      | 68,854    | 53.3      | 14.9                  | 53.1      |           |           |
| Cultipacking or rolling             | .....           | 7,644        | .6                          | 1.2       | 5,302     | 69.4      | 1.1                   | 4.1       |           |           |
| Leveling                            | .....           | 57,198       | 4.3                         | 9.0       | 15,030    | 26.3      | 3.3                   | 11.6      |           |           |
| Diking                              | .....           | 5,129        | .4                          | .8        | 1,918     | 37.4      | .4                    | 1.5       |           |           |
| Corrugating                         | .....           | 49,873       | 3.8                         | 7.9       | 34,884    | 70.0      | 7.6                   | 26.9      |           |           |
| Miscellaneous operations            | .....           | 5,126        | .4                          | .8        | 459       | 9.0       | .1                    | .3        |           |           |
| Total land preparation              | .....           | 633,018      | 48.1                        | 100.0     | 129,783   | 20.5      | 28.1                  | 100.0     |           |           |
| Total planting                      | .....           | 87,092       | 6.6                         | ---       | 51,179    | 58.8      | 11.1                  | ---       |           |           |
| Total crop cultivation              | .....           | 243,954      | 18.6                        | ---       | 97,374    | 39.9      | 21.1                  | ---       |           |           |
| Haying                              | .....           | 194,243      | 14.8                        | 55.4      | 123,980   | 63.8      | 26.8                  | 67.5      |           |           |
| Combining                           | .....           | 11,395       | .9                          | 3.3       | ---       | ---       | ---                   | ---       |           |           |
| Digging potatoes                    | .....           | 65,009       | 5.0                         | 18.6      | 6,919     | 10.6      | 1.5                   | 3.8       |           |           |
| Lifting beets                       | .....           | 37,830       | 2.9                         | 10.8      | 27,053    | 71.5      | 5.9                   | 14.7      |           |           |
| Culling and raking beans            | .....           | 16,991       | 1.3                         | 4.8       | 14,530    | 85.5      | 3.2                   | 7.9       |           |           |
| Binding grain and corn              | .....           | 21,435       | 1.6                         | 6.1       | 8,735     | 40.8      | 1.9                   | 4.8       |           |           |
| Lifting onions                      | .....           | 1,217        | .2                          | 1.0       | 686       | 56.4      | .4                    | 1.3       |           |           |
| Miscellaneous harvesting operations | .....           | 2,423        | ---                         | ---       | 1,776     | 73.3      | ---                   | ---       |           |           |
| Total harvesting                    | .....           | 350,545      | 26.7                        | 100.0     | 183,679   | 52.4      | 39.7                  | 100.0     |           |           |
| Total all field operations          | .....           | 1,314,637    | 100.0                       | ---       | 462,015   | 35.1      | 100.0                 | ---       |           |           |

For animal power the importance of major groups of field operations and individual jobs differed from that for mechanical power. Although spiketooth harrowing was the main individual job, more animal power was used in various haying operations combined. In general, preparation of land required only somewhat more than a fourth of all horse work. Light leveling jobs and corrugating were most important in addition to harrowing. When horses were used for heavy work the average acreage covered during the season by such operations was generally small. Horses were most frequently used for harvesting operations. In addition to haying jobs such as mowing, raking, and bunching, lifting beets, cutting and raking beans, and binding grain were the major harvest operations. Row crops were frequently cultivated with horses. Beets, beans, and corn were more often cultivated with horses but the average acreage covered was smaller than when these jobs were done by tractors. In total, one-fifth of all horse work was for crop cultivation. Planting operations required less than 10 percent of the total energy for field work, but the use of horses in these operations was relatively important. Except for planting potatoes on large acreages, horses were more frequently used for the various planting operations than were tractors.

The relative importance of individual field operations or groups of operations is shown by combining all field work performed by tractors and horses. Operations incidental to preparing the land used almost 50 percent of all the energy for field work, plowing alone used more than a fourth, and harrowing more than one-tenth of the total. Planting operations used only a small amount of power. Here it was not so much a problem of high energy requirement as of timeliness of operation. Cultivation of row crops used a relatively large amount of power, and operations were extended over a long period during the season. Harvesting operations not only required much work--more than a fourth of the total for field work--they were also important with regard to timeliness of operation. On irrigated farms, haying and digging of potatoes and beets were the chief operations during harvest.

In table 9 is presented a comparison of selected field operations for which both tractors and horses were used sufficiently often to permit comparisons in rates. The number of cases in which tractors were used was generally larger for the larger size implements of a specific kind; the reverse was true for operations performed

Table 9.- Comparison of average rates of performance of tractors and horses for selected field operations, three major irrigated areas, southern Idaho, 1940

| Field operation            | Width of implement | Number of cases | Average size   |                | Acres per 10-hour day | Energy consumption |                |
|----------------------------|--------------------|-----------------|----------------|----------------|-----------------------|--------------------|----------------|
|                            |                    |                 | Tractor:Horses | Tractor:Horses |                       | Tractor:Horses     | HP :Horse: EHP |
|                            |                    | Number          | Number:rating  | Number         | Acres                 | hours              | hours:hours    |
| Harrowing--                |                    | 49              | 82             | 11.98          | 33.7                  | 18.0               | 2.7 1.7 2.5    |
| spiketooth . . .           | 2-section          |                 |                |                |                       |                    |                |
| Cultipacking or            |                    |                 |                |                |                       |                    |                |
| rolling . . .              | 8-foot             | 7               | 29             | 10.11          | 27.8                  | 18.2               | 3.1 1.2 2.7    |
| Leveling . . .             | 8-foot             | 59              | 23             | 13.92          | 23.9                  | 15.2               | 3.9 2.4 4.4    |
|                            | 10-foot            | 31              | 20             | 14.01          | 32.2                  | 17.0               | 3.9 2.4 4.4    |
| Corrugating . . .          | 3-row              | 19              | 52             | 12.04          | 21.5                  | 12.3               | 4.4 1.9 3.6    |
|                            | 4-row              | 46              | 56             | 11.83          | 26.0                  | 14.8               | 3.5 1.6 3.4    |
| Drilling grain . .         | 6-foot             | 24              | 62             | 11.54          | 20.1                  | 11.3               | 4.6 2.2 3.9    |
|                            | 7-foot             | 18              | 29             | 14.87          | 25.6                  | 11.9               | 4.5 2.3 4.0    |
|                            | 8-foot             | 38              | 46             | 13.16          | 24.9                  | 14.1               | 4.2 2.6 4.7    |
| Planting potatoes          | 1-row              | 10              | 76             | 11.21          | 8.6                   | 5.5                | 9.6 4.0 8.2    |
|                            | 2-row              | 77              | 6              | 14.12          | 14.5                  | 9.7                | 7.8 3.8 7.5    |
| Planting beets . .         | 4-row              | 28              | 85             | 11.94          | 21.4                  | 12.1               | 4.3 1.8 4.4    |
| Planting beans . .         | 4-row              | 10              | 64             | 11.30          | 19.0                  | 14.2               | 4.7 1.5 4.3    |
| Cultivating potatoes . . . |                    |                 |                |                |                       |                    |                |
|                            | 1-row              | 19              | 64             | 12.13          | 11.9                  | 6.3                | 7.3 3.5 5.3    |
|                            | 2-row              | 86              | 4              | 13.66          | 19.9                  | 8.4                | 5.3 2.8 5.4    |
| Cultivating beets          | 4-row              | 61              | 76             | 11.85          | 20.8                  | 11.4               | 4.7 1.8 4.5    |
| Cultivating beans          | 4-row              | 28              | 52             | 11.84          | 23.4                  | 14.4               | 4.1 1.5 4.0    |
| Mowing alfalfa . .         | 5-foot             | 21              | 113            | 11.43          | 16.7                  | 9.9                | 4.9 2.1 4.4    |
|                            | 6-foot             | 23              | 11             | 11.29          | 21.0                  | 11.3               | 4.3 1.8 3.6    |
|                            | 8-foot             | 9               | 38             | 12.88          | 27.3                  | 16.8               | 3.3 1.3 3.0    |
|                            | 9-foot             | 13              | 45             | 11.84          | 30.7                  | 17.6               | 2.8 1.2 2.9    |
|                            | 10-foot            | 12              | 120            | 11.08          | 35.3                  | 19.0               | 2.4 1.1 2.7    |
| Binding grain . . .        | 5-foot             | 7               | 6              | 12.88          | 15.0                  | 8.8                | 4.3 1.1 4.3    |
|                            | 6-foot             | 38              | 36             | 14.35          | 16.3                  | 10.8               | 6.9 3.2 6.2    |
|                            | 7-foot             | 12              | 7              | 13.31          | 18.7                  | 11.9               | 5.2 3.4 6.6    |
| Digging potatoes           | 1-row              | 123             | 21             | 14.15          | 7.0                   | 4.3                | 17.2 10.4 17.0 |
| Lifting beets . . .        | 1-row              | 13              | 85             | 12.22          | 5.5                   | 3.3                | 17.8 7.8 15.9  |
| Cutting beans . . .        | 4-row              | 15              | 27             | 11.42          | 22.6                  | 13.2               | 3.7 1.6 2.8    |



by horses. For example, the common implement for planting potatoes with a tractor was a two-row planter, whereas one-row planters were used with horses. The average tractor had a rating of 10 to 15 DBHP, while a two-horse team was most common except for very light work such as raking hay, for which one horse was sometimes employed. Three- and four-horse teams were used for heavy work such as digging potatoes, planting potatoes, leveling, and binding grain.

In all comparable field operations, the tractor accomplished from one-and-one-half to almost twice as much work per 10-hour day as horses. However, consumption of energy by horses per acre, as expressed in equivalent horsepower hours, was frequently lower than the energy consumed by tractors. Exceptions to this were operations that constituted relatively heavy work for horses, considering the size of implement used.

#### Horsepower Hours Used in Production of Major Crops

Calculation of horsepower hours from the amount of fuel used by tractors and conversion of horse-hours into equivalent horsepower hours makes it further possible to determine the total number of horsepower hours per acre for the various crops grown in the area studied. In order to eliminate as much as possible of the variation due to soil conditions, size of operation, and size of power, and still retain a sample large enough to obtain satisfactory averages, horsepower hours per acre of the major crops are given in the discussions that follow, both for crops in individual subareas where they were important and for the irrigated areas of southern Idaho as a whole. Table 10 shows horsepower hours used by groups of field operations for selected crops. Field operations do not include hauling the harvested crop from the field.

Production of wheat on irrigated farms in southern Idaho is important in the Upper Snake River Area. Fields in this area are relatively large. Of the 78 farms on which wheat was grown, 70 farms used horses for some of the operations necessary to grow the crop, while tractors were used in production of wheat on all farms. In preparing the land, all farms used tractors but less than half used horses also, chiefly for harrowing. In planting, horses were used on two-thirds of the farms, and when cultivating was done, such as corrugating, horses did this work more often than tractors. In harvesting, tractors were more commonly used,

Table 10.-- Horsepower hours used by major groups of field operations for selected crops, by major irrigated areas, southern Idaho, 1940

| Item                   | Farms          |          | HP hours used per |           | Total |          | Percentage of |  |
|------------------------|----------------|----------|-------------------|-----------|-------|----------|---------------|--|
|                        | reporting      | use of   | acre per farm     | reporting | HP    | work     | HP hours      |  |
|                        |                |          |                   |           | hours | done     | used for      |  |
|                        | Tractor:Horses | Tractor: | Horse             |           | per   | by       | specified     |  |
|                        |                |          |                   |           | acre  | tractor: | crop          |  |
|                        | Number         | Number   | hours             | hours     | hours | Percent  | Percent       |  |
| Upper Snake-River Area |                |          |                   |           |       |          |               |  |
| Wheat                  |                |          |                   |           |       |          |               |  |
| Land preparation       | 78             | 36       | 17.1              | 4.6       | 7.3   | 20.5     | 45.5          |  |
| Planting               | 26             | 52       | 4.8               | 2.5       | 4.8   | 4.8      | 10.8          |  |
| Cultivation            | 16             | 47       | 3.8               | 1.8       | 3.5   | 2.9      | 6.4           |  |
| Harvesting             | 78             | 10       | 16.1              | 10.6      | 21.3  | 16.7     | 37.3          |  |
| All operations         | 78             | 70       | 33.4              | 7.0       | 12.7  | 44.9     | 100.0         |  |
| Potatoes               |                |          |                   |           |       |          |               |  |
| Land preparation       | 80             | 53       | 30.3              | 5.4       | 8.3   | 35.8     | 40.4          |  |
| Planting               | 35             | 45       | 7.8               | 4.0       | 8.0   | 7.9      | 8.9           |  |
| Cultivation            | 50             | 58       | 25.8              | 9.9       | 15.9  | 27.7     | 31.3          |  |
| Harvesting             | 64             | 16       | 17.2              | 10.9      | 17.4  | 17.2     | 19.4          |  |
| All operations         | 80             | 70       | 63.6              | 17.3      | 28.6  | 88.6     | 100.0         |  |
| Sugar beets            |                |          |                   |           |       |          |               |  |
| Land preparation       | 51             | 38       | 23.5              | 8.0       | 12.5  | 32.8     | 42.2          |  |
| Planting               | 4              | 47       | 4.3               | 1.9       | 4.8   | 4.7      | 6.1           |  |
| Cultivation            | 14             | 41       | 23.4              | 9.4       | 18.6  | 25.0     | 32.3          |  |
| Harvesting             | 7              | 44       | 15.0              | 7.2       | 15.1  | 15.1     | 19.4          |  |
| All operations         | 51             | 51       | 32.3              | 21.5      | 45.3  | 77.6     | 100.0         |  |
| (Continued)            |                |          |                   |           |       |          |               |  |

(Continued)





even though in 1940 on only 13 percent of the farms studied, the wheat was harvested with combines. When binders were used, tractors were employed in the same number of cases as horses, but all threshing with stationary threshers was done with tractors.

Fields were plowed on about half of the farms; on the other half, fields were tilled with a deep tiller, disked, or merely cultivated; or a combination of tillage operations was used. This generally resulted in lower horsepower hours per acre than if all fields had been plowed. Whether plowing is necessary depends primarily upon the preceding crop and the condition of the land. In the Upper Snake River Area, in most cases, wheat followed a row crop; in a few cases, it followed a grain crop. When wheat followed a row crop, it was frequently not necessary to plow, but cultivators, disks, and harrows could be used for the proper preparation of a seed bed. When harrowing was done, it was generally performed twice or more, either by overlapping or by harrowing at different times in opposite directions.

To produce an acre of wheat 45 HP hours were used, of which tractors contributed three-fourths. Tractors were not used much in planting and cultivating the crop; for the major energy-consuming jobs included in land preparation and harvesting, their use was relatively high. Slightly more than 45 percent of the total work done per acre was needed for land preparation, planting required only 11 percent, and cultivating only 6 percent. The harvesting of wheat, which required 37 percent of the total horsepower hours, was again a heavy load upon power resources. In general, consumption of energy for grain crops was not as high as that for other crops grown, except possibly for alfalfa.

Potatoes were generally grown after alfalfa, and required considerable work to prepare the land for an adequate seed bed. All fields were plowed and on some this work was preceded by a shallow plowing, commonly referred to as crowning alfalfa, or by disking. Frequent harrowing was also more common on potato fields than on fields prepared for grain. Horses were used for harrowing and leveling. Planting potatoes was more frequently done with horses than with tractors, and even for cultivating, horses contributed a large amount of the power needed. The potatoes were harvested mainly by tractors. Considering all field operations, horses were used in potato production in 70 out of a total of 80 cases.

Total consumption of energy per acre of potatoes reached 88 HP hours, the highest of any major crop grown. Forty-one percent was used in land preparation, 9 percent in planting, 31 percent in crop cultivation, and almost 20 percent in harvesting. Tractors furnished less than three-fourths of the horsepower hours.

Sugar beets were grown on 51 of the farms located in the Upper Snake River Area. The average size of field was nearly 22 acres. In almost all cases sugar beets followed potatoes. Therefore, fields were not plowed in all instances, and if they were, the additional land preparation was not large. Horses were used on all of the fields on which this crop was grown, mainly in planting, cultivating, and lifting. Tractors were important only in preparing the land.

Of a total of 78 HP hours consumed per acre of sugar beets, only 42 percent was contributed by tractors. Next to the proportion of the use of tractors on alfalfa fields, this was the lowest for any major crop. Of total consumption of energy by tractors and horses, 42 percent was used in land preparation, 6 percent in planting, 32 percent in crop cultivation, and almost 20 percent in harvesting.

Alfalfa was grown at some time in the rotation on every irrigated farm. Average horsepower used by groups of operations is given for 43 fields in the Upper Snake River Area where two cuttings were generally made and on 91 fields in the Twin Falls-Minidoka Area where three cuttings were made. As alfalfa was seeded with grain as a nurse crop, operations included only those of an established stand. Little cultivating and corrugating work was done. Less than a third of the fields were harrowed with springtooth harrows, an operation commonly referred to as renovating. Other cultivating implements were fairly insignificant, but many fields required corrugation to prepare them for irrigation. Except for corrugating in the Twin Falls-Minidoka Area, tractors were most commonly used for cultivating work on alfalfa fields. For harvesting operations, on the other hand, horses were generally the more important source of power. For mowing alfalfa, however, many farmers preferred tractors to horses because of the greater speed with which the work could be done.

Total consumption of energy for harvesting two cuttings of alfalfa (exclusive of loading and hauling) in the Upper Snake River Area amounted to nearly 22 HP hours, of which 12 percent were used in



cultivating the crop. Tractor power represented somewhat more than a third of the total. In the Twin Falls-Minidoka Area, total consumption of energy per acre for three cuttings of alfalfa amounted to 32 HP hours, of which 17 percent was used in cultivating the crop. The use of tractors, which amounted to only a third of the total horsepower hours per acre, was slightly less important. This may seem surprising in an area in which mechanization and the use of mechanical power had started earlier and had progressed further, but the reason for it lies in the fact that when work on alfalfa fields had to be done, mechanical power was engaged in important operations on other field crops.

Production of beans was important in the Twin Falls-Minidoka Area only. Horsepower hours per acre were relatively high because of the large amounts of energy needed for proper preparation of the seed bed. Beans either followed alfalfa or were grown for several years in succession. Horses were important in corrugating, planting, cultivating, and cutting. On less than a fourth of the fields the crop was harvested with combines.

Total consumption of energy per acre of beans amounted to 78 HP hours, of which 62 percent was contributed by tractors. Almost half of the total was used in preparing the land, 6 percent in planting, 22 percent in crop cultivation, and 23 percent in harvesting.

Table 11 gives average horsepower hours per acre for specified crops in the three areas combined. The variation from energy consumption for individual crops grown in individual areas, as previously discussed, in all instances was relatively minor. Barley has been added in this table to show the difference in horsepower hours per acre from the main grain-crop grown--wheat. The slightly higher average number of horsepower hours per acre for barley was because more energy was used in preparing the land. Although most of the wheat was grown after row crops, thus requiring less seed bed preparation, a relatively large number of barley fields followed wheat, which required more intensive work in land preparation.

Figure 3 shows graphically the magnitude of major groups of field operations in relation to total horsepower hours per acre for individual crops and the relative importance of animal power on the so-called tractor farms. In cultivating and harvesting operations of row crops and in harvesting operations of alfalfa, horses were extensively used.



Table 11.- Average horsepower hours per acre of specified crops and percentage distribution by major groups of field operations, southern Idaho, 1940

| Crop                | Number of cases | Horsepower hours used in |                     |                  |         |          |         |
|---------------------|-----------------|--------------------------|---------------------|------------------|---------|----------|---------|
|                     |                 | Horsepower               |                     | Land preparation |         | Planting |         |
|                     |                 | Number                   | Percent             | Number           | Percent | Number   | Percent |
| Wheat               | 224             | 44.3                     | 49.7                | 9.4              | 8.4     | 32.5     | 100.0   |
| Barley              | 105             | 47.2                     | 53.2                | 9.0              | 8.0     | 29.8     | 100.0   |
| Potatoes            | 170             | 89.7                     | 41.3                | 8.9              | 30.8    | 19.0     | 100.0   |
| Sugar beets         | 119             | 78.1                     | 42.1                | 5.7              | 32.5    | 19.7     | 100.0   |
| Beans               | 76              | 77.6                     | 49.5                | 5.7              | 21.9    | 22.9     | 100.0   |
| Alfalfa, 2 cuttings | 52              | 21.0                     | (Established stand) | 13.9             | 86.1    |          | 100.0   |
| Alfalfa, 3 cuttings | 203             | 30.4                     | (Established stand) | 14.6             | 85.4    |          | 100.0   |



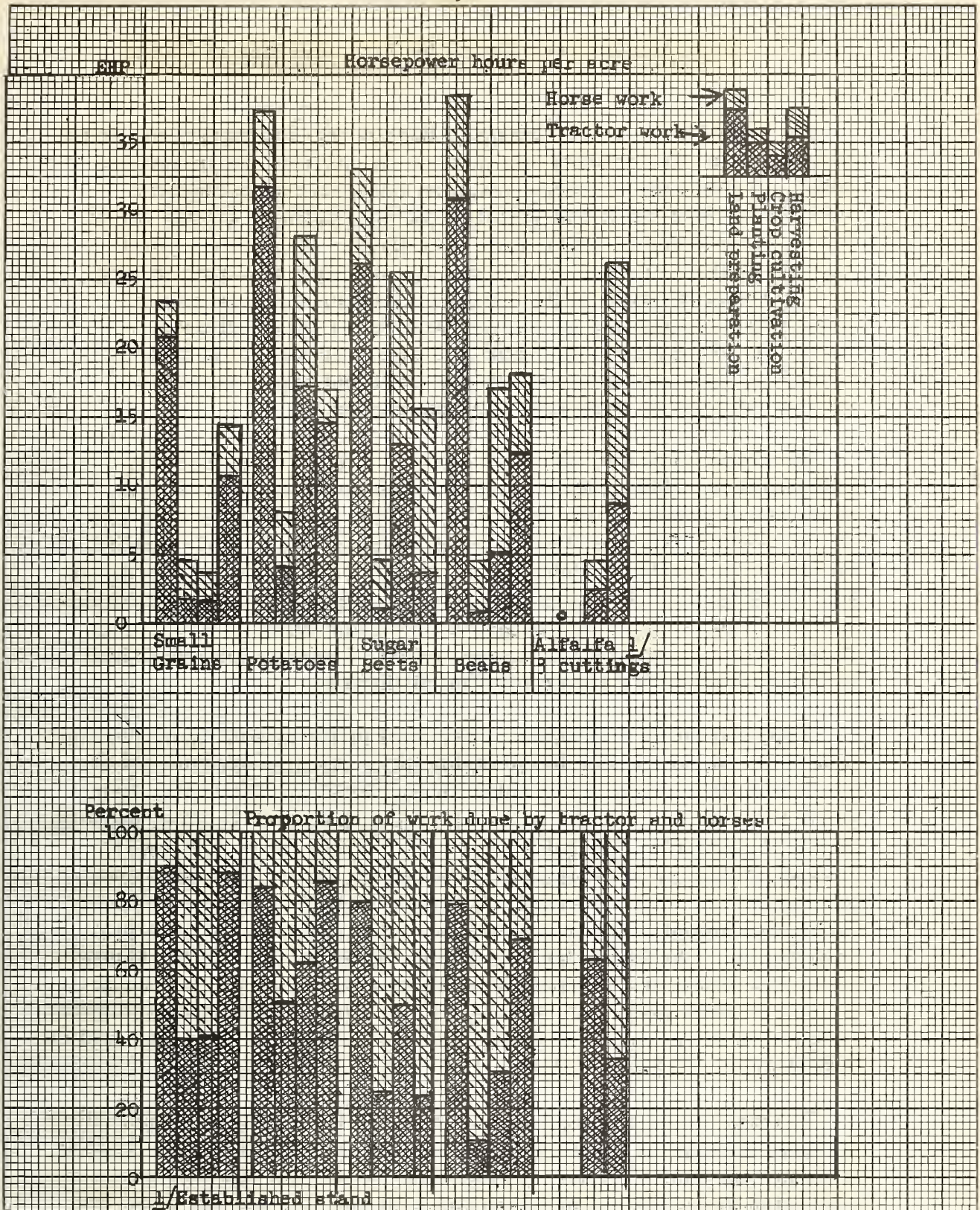


Figure 3.- Horsepower hours per acre of specified crops by major groups of field operations and proportion of work done by tractors and horses, three major irrigated areas, southern Idaho, 1940



### Total Horsepower Hours by Type and Size of Farm

In addition to use for drawbar field work, tractors were used for belt work and hauling and horses chiefly for minor hauling jobs. In this type of work, tractors competed with electric motors for belt work and with trucks for hauling. On the other hand, some field or other work was hired. Therefore, total consumption of energy by mechanical and animal power on any given farm consisted of field work and other work by power owned by the operator as well as work done by hired power. From the viewpoint of the total use of power owned by a farm operator, use on the farm both for field and other work and amount of custom work must be considered.

In tables 12 to 15, all work done by tractors and horses, both from the viewpoint of work done by available power and total use of power on the particular farm, is shown by type and size of farm. To facilitate a comparison of the use of tractors on farms in southern Idaho with that found in studies of a similar type in other areas, use of tractors is shown both in tractor hours (table 13) and in horsepower hours by major types of work done (table 12). An estimate of consumption of energy for work done by hired tractors is shown only in HP hours.

Approximately 9 percent of the energy developed by mechanical power on all farms was hired (table 12). Energy used for field work was 70 percent of the total energy used on all farms, belt work constituted nearly 9 percent, and other work such as hauling, about 12 percent. Specialized livestock farms used the lowest amount of energy developed by mechanical power per farm and per cultivated acre. Cash-crop farms used less total energy per farm than mixed cash crop-livestock farms, but more on a per acre basis. The latter had the largest total number of horsepower hours for tractors per farm but a somewhat lower per acre use compared with cash-crop farms. Cash-crop farms had the highest proportion of energy used in field work--almost 73 percent--and the lowest proportion for belt and other work on farms.

Tractor hours of farm-owned tractors (table 13), because of an increase in size of power unit, declined per cultivated acre with an increase in size of farm. On the other hand, horsepower hours per cultivated acre, including hired work (table 12), did not show the same reduction by size of farm. There appeared to be a variation in the same direction, but it was irregular and less noticeable. The



Table 12.- Average horsepower hours used per farm for major types of work and by type and size of farm, three major irrigated areas, southern Idaho, 1940

| Type and size of farm<br>(cultivated acres) | Number<br>of<br>farms | Field work |        |        | Belt work |        |        | Other work |        |        | All work<br>by own |        |        | All work<br>by opera- |        |        | Hired work |        |        | Total  |        |        | Per cul- |        |  |
|---|-----------------------|------------|--------|--------|-----------|--------|--------|------------|--------|--------|--------------------|--------|--------|-----------------------|--------|--------|------------|--------|--------|--------|--------|--------|----------|--------|--|
|   |                       | HP hr.     | HP hr. | HP hr. | HP hr.    | HP hr. | HP hr. | HP hr.     | HP hr. | HP hr. | HP hr.             | HP hr. | HP hr. | HP hr.                | HP hr. | HP hr. | HP hr.     | HP hr. | HP hr. | HP hr. | HP hr. | HP hr. | HP hr.   | HP hr. |  |
| Livestock farms                             |                       |            |        |        |           |        |        |            |        |        |                    |        |        |                       |        |        |            |        |        |        |        |        |          |        |  |
| Under 50 acres                              | 8                     | 579        | 334    | 362    | 1,275     | 2,028  | 3,303  | 1,417      | 1,417  | 1,417  | 1,417              | 1,417  | 1,417  | 1,417                 | 1,417  | 1,417  | 1,417      | 1,417  | 1,417  | 1,417  | 1,417  | 1,417  | 1,417    | 1,417  |  |
| 50-74 acres                                 | 12                    | 1,637      | 82     | 434    | 2,153     | 1,123  | 3,276  | 384        | 384    | 384    | 384                | 384    | 384    | 384                   | 384    | 384    | 384        | 384    | 384    | 384    | 384    | 384    | 384      | 384    |  |
| 75-99 acres                                 | 8                     | 2,336      | 188    | 116    | 2,640     | 92     | 2,732  | 481        | 481    | 481    | 481                | 481    | 481    | 481                   | 481    | 481    | 481        | 481    | 481    | 481    | 481    | 481    | 481      | 481    |  |
| 100-124 acres                               | 2                     | 2,702      | 94     | 1,412  | 4,208     | 529    | 4,737  | 529        | 529    | 529    | 529                | 529    | 529    | 529                   | 529    | 529    | 529        | 529    | 529    | 529    | 529    | 529    | 529      | 529    |  |
| 125-149 acres                               | 3                     | 4,253      | 1,472  | 668    | 6,393     | ---    | 6,393  | 326        | 326    | 326    | 326                | 326    | 326    | 326                   | 326    | 326    | 326        | 326    | 326    | 326    | 326    | 326    | 326      | 326    |  |
| 150-199 acres                               | 2                     | 2,960      | ---    | 581    | 3,541     | 2,489  | 6,030  | 616        | 616    | 616    | 616                | 616    | 616    | 616                   | 616    | 616    | 616        | 616    | 616    | 616    | 616    | 616    | 616      | 616    |  |
| 200 acres and over                          | 1                     | 1,650      | 1,558  | ---    | 3,208     | 4,956  | 8,164  | 210        | 210    | 210    | 210                | 210    | 210    | 210                   | 210    | 210    | 210        | 210    | 210    | 210    | 210    | 210    | 210      | 210    |  |
| Average                                     | 36                    | 1,908      | 314    | 417    | 2,639     | 1,151  | 3,790  | 363        | 363    | 363    | 363                | 363    | 363    | 363                   | 363    | 363    | 363        | 363    | 363    | 363    | 363    | 363    | 363      | 363    |  |
| Percentage of total                         |                       | 65.5       | 10.5   | 13.9   | 84.9      | 12.1   | 100.0  |            |        |        |                    |        |        |                       |        |        |            |        |        |        |        |        |          |        |  |
| Cash-crop farms                             |                       |            |        |        |           |        |        |            |        |        |                    |        |        |                       |        |        |            |        |        |        |        |        |          |        |  |
| Under 50 acres                              | 15                    | 1,496      | 51     | 407    | 1,954     | 1,553  | 3,507  | 224        | 224    | 224    | 224                | 224    | 224    | 224                   | 224    | 224    | 224        | 224    | 224    | 224    | 224    | 224    | 224      | 224    |  |
| 50-74 acres                                 | 42                    | 2,089      | 132    | 258    | 2,479     | 1,911  | 4,390  | 291        | 291    | 291    | 291                | 291    | 291    | 291                   | 291    | 291    | 291        | 291    | 291    | 291    | 291    | 291    | 291      | 291    |  |
| 75-99 acres                                 | 26                    | 2,958      | 326    | 588    | 3,872     | 684    | 4,556  | 359        | 359    | 359    | 359                | 359    | 359    | 359                   | 359    | 359    | 359        | 359    | 359    | 359    | 359    | 359    | 359      | 359    |  |
| 100-124 acres                               | 18                    | 3,463      | 239    | 439    | 4,141     | 324    | 4,465  | 477        | 477    | 477    | 477                | 477    | 477    | 477                   | 477    | 477    | 477        | 477    | 477    | 477    | 477    | 477    | 477      | 477    |  |
| 125-149 acres                               | 20                    | 4,552      | 748    | 705    | 6,005     | 134    | 6,139  | 680        | 680    | 680    | 680                | 680    | 680    | 680                   | 680    | 680    | 680        | 680    | 680    | 680    | 680    | 680    | 680      | 680    |  |
| 150-199 acres                               | 13                    | 6,178      | 377    | 756    | 7,311     | 598    | 7,909  | 454        | 454    | 454    | 454                | 454    | 454    | 454                   | 454    | 454    | 454        | 454    | 454    | 454    | 454    | 454    | 454      | 454    |  |
| 200 acres and over                          | 3                     | 7,103      | 501    | 1,963  | 9,567     | 869    | 10,436 | 148        | 148    | 148    | 148                | 148    | 148    | 148                   | 148    | 148    | 148        | 148    | 148    | 148    | 148    | 148    | 148      | 148    |  |
| Average                                     | 137                   | 3,227      | 295    | 510    | 4,032     | 1,024  | 5,056  | 397        | 397    | 397    | 397                | 397    | 397    | 397                   | 397    | 397    | 397        | 397    | 397    | 397    | 397    | 397    | 397      | 397    |  |
| Percentage of total                         |                       | 72.8       | 6.7    | 11.5   | 91.0      | 9.0    | 100.0  |            |        |        |                    |        |        |                       |        |        |            |        |        |        |        |        |          |        |  |

(Continued)

(Continued)







Table 13.- (Continued). Average number of hours tractors used for major types of work by type and size of farm, three major irrigated areas, southern Idaho, 1940

| Type and size of farm<br>(cultivated acres) | Number |   | Field |   | Belt |   | Other |   | Work on opera- |   | Custom:by oper- |      |
|---|--------|---|-------|---|------|---|-------|---|----------------|---|-----------------|------|
|   | :      | : | :     | : | :    | : | :     | : | :              | : | :               |      |
|   |        |   |       |   |      |   |       |   |                |   |                 | work |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
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| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    | : | :     | : | :              | : | :               | :    |
| :   | :      | : | :     | : | :    |   |       |   |                |   |                 |      |

Table 14.- Average number of horse hours per farm for major types of work and by type and size of farm and EHP hours per cultivated acre, three major irrigated areas, southern Idaho, 1940

| Type and size<br>of farm<br>(cultivated acres) | Farms  | Work by    |       | Hired<br>work | All work on     |               |                       |
|--|--------|------------|-------|---------------|-----------------|---------------|-----------------------|
|  |        | operators' |       |               | operators' farm |               |                       |
|  |        | horses     |       |               | Total           | Work per cul- |                       |
|  |        | Field      | Other |               |                 | tivated acre  |                       |
|  | Number | Hours      | Hours | Hours         | Hours           | Hours         | EHP hr. <sup>1/</sup> |
| Livestock farms                                |        |            |       |               |                 |               |                       |
| Under 50 acres . . .                           | 8      | 181        | 247   | 2             | 430             | 14.2          | 28.6                  |
| 50-74 acres . . .                              | 12     | 272        | 349   | 93            | 714             | 11.5          | 23.1                  |
| 75-99 acres . . .                              | 8      | 398        | 908   | 60            | 1,366           | 15.6          | 32.8                  |
| 100-124 acres . . .                            | 2      | 504        | 82    | 80            | 666             | 5.8           | 11.3                  |
| 125-149 acres . . .                            | 3      | 609        | 1,504 | ---           | 2,113           | 14.9          | 31.7                  |
| 150-199 acres . . .                            | 2      | 1,220      | 1,770 | ---           | 2,990           | 17.4          | 35.2                  |
| 200 and over . . .                             | 1      | 965        | 3,700 | 1,800         | 6,465           | 29.4          | 67.0                  |
| Average . . . . .                              | 36     | 393        | 704   | 99            | 1,196           | 14.8          | 31.0                  |
| Percentage of<br>total . . . . .               |        | 32.8       | 58.9  | 8.3           | 100.0           |               |                       |
| Cash-crop farms                                |        |            |       |               |                 |               |                       |
| Under 50 acres . . .                           | 15     | 302        | 277   | 44            | 623             | 16.5          | 33.8                  |
| 50-74 acres . . .                              | 42     | 634        | 600   | 40            | 1,274           | 19.7          | 40.9                  |
| 75-99 acres . . .                              | 26     | 756        | 628   | 36            | 1,420           | 16.7          | 33.3                  |
| 100-124 acres . . .                            | 18     | 1,276      | 692   | 19            | 1,987           | 17.9          | 34.4                  |
| 125-149 acres . . .                            | 20     | 1,400      | 1,000 | 14            | 2,414           | 17.8          | 34.3                  |
| 150-199 acres . . .                            | 13     | 1,730      | 732   | ---           | 2,462           | 14.7          | 27.8                  |
| 200 and over . . .                             | 3      | 1,885      | 1,853 | 57            | 3,795           | 15.8          | 34.4                  |
| Average . . . . .                              | 137    | 948        | 680   | 30            | 1,658           | 17.3          | 34.4                  |
| Percentage of<br>total . . . . .               |        | 57.2       | 41.0  | 1.8           | 100.0           |               |                       |
| Mixed cash-crop-<br>livestock farms            |        |            |       |               |                 |               |                       |
| Under 50 acres . . .                           | 8      | 112        | 167   | 148           | 427             | 10.2          | 22.9                  |
| 50-74 acres . . .                              | 29     | 511        | 554   | 38            | 1,103           | 17.2          | 35.5                  |
| 75-99 acres . . .                              | 16     | 808        | 732   | 14            | 1,554           | 18.0          | 36.8                  |
| 100-124 acres . . .                            | 9      | 1,028      | 1,253 | 27            | 2,308           | 20.1          | 41.7                  |
| 125-149 acres . . .                            | 21     | 1,159      | 934   | 77            | 2,170           | 16.3          | 32.7                  |
| 150-199 acres . . .                            | 12     | 1,880      | 1,964 | ---           | 3,844           | 22.3          | 45.0                  |
| 200 and over . . .                             | 9      | 2,452      | 1,528 | 10            | 3,990           | 16.6          | 32.0                  |
| Average . . . . .                              | 104    | 1,027      | 936   | 43            | 2,006           | 17.9          | 36.2                  |
| Percentage of<br>total . . . . .               |        | 51.2       | 46.7  | 2.1           | 100.0           |               |                       |
| Total all types                                |        |            |       |               |                 |               |                       |
| Under 50 acres . . .                           | 31     | 222        | 241   | 60            | 523             | 14.2          | 29.5                  |
| 50-74 acres . . .                              | 83     | 539        | 548   | 47            | 1,134           | 17.7          | 36.6                  |
| 75-99 acres . . .                              | 50     | 715        | 706   | 33            | 1,454           | 16.9          | 34.4                  |
| 100-124 acres . . .                            | 29     | 1,146      | 824   | 26            | 1,996           | 17.7          | 35.6                  |
| 125-149 acres . . .                            | 44     | 1,231      | 1,003 | 43            | 2,277           | 16.9          | 33.4                  |
| 150-199 acres . . .                            | 27     | 1,759      | 1,356 | ---           | 3,115           | 18.3          | 36.1                  |
| 200 and over . . .                             | 13     | 2,207      | 1,770 | 159           | 4,136           | 17.3          | 35.0                  |
| Average . . . . .                              | 277    | 906        | 779   | 44            | 1,729           | 17.3          | 34.8                  |
| Percentage of<br>total . . . . .               |        | 52.4       | 45.1  | 2.5           | 100.0           |               |                       |

1/ Horse-hours converted to equivalent horsepower hours for each individual operation based on comparable amount of work done by mechanical power

Table 15.- Average energy consumption of tractors and horses for major types of work and by type and size of farm, three major irrigated areas, southern Idaho, 1940

| Type and size of farm<br>(cultivated acres) | Farms  | All work: |         |         | All work by: |         |          | All work on |            |          |
|---|--------|-----------|---------|---------|--------------|---------|----------|-------------|------------|----------|
|   |        | Field     | Other   | by own  | power on:    | Custom: | work by: | Hired       | operators' | farm     |
|   |        | work      | work    | power   | opera-       | work    | opera-   | work        | work       | Per cul- |
|   |        |           |         |         | tors'        |         | tors'    |             |            | tivated  |
|   |        |           |         |         | farms        |         |          |             |            | acre     |
|   | Number | EHP hr.   | EHP hr. | EHP hr. | EHP hr.      | EHP hr. | EHP hr.  | EHP hr.     | EHP hr.    | EHP hr.  |
| <b>Livestock farms</b>                      |        |           |         |         |              |         |          |             |            |          |
| Under 50 acres                              | 8      | 882       | 1,255   | 2,137   | 2,028        | 4,165   | 145      | 2,282       | 75.4       |          |
| 50-74 acres                                 | 12     | 2,116     | 1,309   | 3,425   | 1,123        | 4,548   | 546      | 3,971       | 64.0       |          |
| 75-99 acres                                 | 8      | 3,058     | 2,326   | 5,384   | 92           | 5,476   | 603      | 5,987       | 68.5       |          |
| 100-124 acres                               | 2      | 3,655     | 1,704   | 5,359   | 529          | 5,888   | 673      | 6,032       | 52.7       |          |
| 125-149 acres                               | 3      | 5,168     | 5,708   | 10,876  | ---          | 10,876  | 326      | 11,202      | 79.1       |          |
| 150-199 acres                               | 2      | 5,119     | 4,484   | 9,603   | 2,489        | 12,092  | 616      | 10,219      | 59.4       |          |
| 200 acres and over                          | 1      | 3,738     | 10,068  | 13,806  | 4,956        | 18,762  | 4,350    | 18,156      | 82.5       |          |
| Average                                     | 36     | 2,603     | 2,331   | 4,934   | 1,151        | 6,085   | 568      | 5,502       | 68.2       |          |
| Percentage of total                         |        | 47.3      | 42.4    | 89.7    |              |         | 10.3     | 100.0       |            |          |
| <b>Cash-crop farms</b>                      |        |           |         |         |              |         |          |             |            |          |
| Under 50 acres                              | 15     | 2,063     | 1,087   | 3,150   | 1,553        | 4,703   | 304      | 3,454       | 91.4       |          |
| 50-74 acres                                 | 42     | 3,275     | 1,764   | 5,039   | 1,911        | 6,950   | 374      | 5,413       | 83.8       |          |
| 75-99 acres                                 | 26     | 4,279     | 2,352   | 6,631   | 684          | 7,315   | 427      | 7,058       | 83.1       |          |
| 100-124 acres                               | 18     | 5,782     | 2,151   | 7,933   | 324          | 8,257   | 515      | 8,448       | 75.9       |          |
| 125-149 acres                               | 20     | 6,950     | 3,705   | 10,655  | 134          | 10,789  | 698      | 11,353      | 83.5       |          |
| 150-199 acres                               | 13     | 9,248     | 2,738   | 11,986  | 598          | 12,584  | 454      | 12,440      | 74.0       |          |
| 200 acres and over                          | 3      | 11,361    | 6,387   | 17,748  | 869          | 18,617  | 528      | 18,276      | 76.0       |          |
| Average                                     | 137    | 4,943     | 2,329   | 7,272   | 1,024        | 8,296   | 453      | 7,725       | 80.7       |          |
| Percentage of total                         |        | 64.0      | 30.1    | 94.1    |              |         | 5.9      | 100.0       |            |          |

(Continued)



Table 15.- (Continued). Average energy consumption of tractors and horses for major types of work and by type and size of farm, three major irrigated areas, southern Idaho, 1940

| Type and size of farm<br>(cultivated acres) | Farms  | Field work | Other work | All work:<br>by own power | Custom work | All work by<br>Hired operators | All work on<br>farm | Per cul-<br>tivated<br>acre |
|---|--------|------------|------------|---------------------------|-------------|--------------------------------|---------------------|-----------------------------|
|   | Number | EHP hr.    | EHP hr.    | EHP hr.                   | EHP hr.     | EHP hr.                        | EHP hr.             | EHP hr.                     |
| Mixed cash-crop-livestock farms             |        |            |            |                           |             |                                |                     |                             |
| Under 50 acres                              | 8      | 1,865      | 985        | 2,850                     | 373         | 3,223                          | 500                 | 3,350                       |
| 50-74 acres                                 | 29     | 2,829      | 1,898      | 4,727                     | 738         | 5,465                          | 391                 | 5,118                       |
| 75-99 acres                                 | 16     | 4,097      | 2,293      | 6,390                     | 944         | 7,334                          | 503                 | 6,893                       |
| 100-124 acres                               | 9      | 5,690      | 4,022      | 9,712                     | 872         | 10,584                         | 406                 | 10,118                      |
| 125-149 acres                               | 21     | 6,341      | 3,492      | 9,833                     | 920         | 10,753                         | 465                 | 10,298                      |
| 150-199 acres                               | 12     | 6,917      | 6,348      | 13,265                    | 393         | 13,658                         | 738                 | 14,003                      |
| 200 acres and over                          | 9      | 12,530     | 5,483      | 18,013                    | 8           | 18,021                         | 553                 | 18,566                      |
| Average                                     | 104    | 5,218      | 3,218      | 6,436                     | 687         | 9,123                          | 487                 | 8,923                       |
| Percentage of total                         |        | 58.5       | 36.0       | 94.5                      |             |                                | 5.5                 | 100.0                       |
| Total all types                             |        |            |            |                           |             |                                |                     |                             |
| Under 50 acres                              | 31     | 1,707      | 1,104      | 2,811                     | 1,371       | 4,182                          | 314                 | 3,125                       |
| 50-74 acres                                 | 83     | 2,952      | 1,745      | 4,697                     | 1,387       | 6,084                          | 404                 | 5,101                       |
| 75-99 acres                                 | 50     | 4,026      | 2,329      | 6,355                     | 672         | 7,027                          | 479                 | 6,834                       |
| 100-124 acres                               | 29     | 5,607      | 2,701      | 8,308                     | 508         | 8,816                          | 492                 | 8,800                       |
| 125-149 acres                               | 44     | 6,538      | 3,739      | 10,277                    | 500         | 10,777                         | 561                 | 10,838                      |
| 150-199 acres                               | 27     | 7,906      | 4,472      | 12,378                    | 647         | 13,025                         | 592                 | 12,970                      |
| 200 acres and over                          | 13     | 11,584     | 6,045      | 17,629                    | 587         | 18,216                         | 839                 | 18,468                      |
| Average                                     | 277    | 4,742      | 2,663      | 7,405                     | 914         | 8,319                          | 481                 | 7,886                       |
| Percentage of total                         |        | 60.1       | 33.8       | 93.9                      |             |                                | 6.1                 | 100.0                       |

custom work done on all types of farms by the operator's tractors exceeded the amount used in hired operations. On small farms, except those of a combination type, the amount of custom work was particularly significant.

No custom work was reported for horses available on tractor farms and the amount of horse work hired was only 2.5 percent of the total work performed by horses (table 14). On combination cash-crop-livestock farms, the greatest amount of animal power was used per farm and per acre. On cash-crop farms, the proportion of animal power used in field work was larger than that for other work, totaling more than 50 percent. On the other hand, on specialized livestock and on mixed farms, the average amount of animal power used for other work was considerably larger than that used in field work.

Average consumption of energy per farm for tractors and horses combined, expressed in equivalent horsepower hours, is given in table 15. A decline in total horsepower hours used per acre as the size of farm increases is noticeable. Average consumption of energy per acre was 79 equivalent horsepower hours. It was slightly larger for cash-crop farms than for mixed farms or for specialized livestock farms. The proportion of energy consumed for field work increased as the type of farm changed from a specialized livestock farm to a specialized cash-crop farm. On an average of all farms, 60 percent of the total energy used was spent by the operator's power units in field work. As most of the work hired is also field work, nearly two-thirds of the total consumption of energy was spent in field work.

As previously indicated, the relation between size of farm expressed in cultivated acres and average horsepower hours per farm is close, at least for a specific type of farm in a given area. Although on any one farm, consumption of energy may vary considerably from year to year and may differ from the average of all farms of comparable type and size, averages by size groups indicate that there is a close correlation between size of farm and consumption of energy.

In table 16, average horsepower hours used per farm are given by size groups of farms arranged at 10-acre intervals for cash-crop and combination cash-crop-livestock farms. The number of specialized livestock farms was not considered large enough to show the same relationship. On cash-crop farms of from 30 to 200 acres of

Table 16.- Horsepower per farm by type and size of farm, three major irrigated areas, southern Idaho, 1940

| Size group<br>(cultivated acres) | Cash-crop farms |   |  |        | Mixed cash-crop-livestock farms           |   |  |  |
|----------------------------------|-----------------|---|--|--------|---|---|--|--|
|                                  | Farms.          | Average<br>: size<br>: of farm<br>: Acres | Horsepower:<br>: hours<br>: per farm<br>: HP hours | Farms  | Average<br>: size<br>: of farm<br>: Acres | Horsepower<br>: hours<br>: per farm<br>: HP hours |  |  |
|                                  | Number          |   |  | Number |   |   |  |  |
|                                  |                 |   |  |        |   |   |  |  |
| 30- 39.9                         | 6               | 35.4                                      | 3,695  | 3      | 36.2                                      | 3,816   |  |  |
| 40- 49.9                         | 8               | 42.0                                      | 4,342  | 5      | 45.0                                      | 3,668   |  |  |
| 50- 59.9                         | 11              | 55.8                                      | 6,377  | 8      | 53.4                                      | 6,080   |  |  |
| 60- 69.9                         | 15              | 64.7                                      | 6,265  | 11     | 64.8                                      | 5,501   |  |  |
| 70- 79.9                         | 24              | 73.7                                      | 6,463  | 13     | 72.6                                      | 5,967   |  |  |
| 80- 89.9                         | 4               | 84.1                                      | 8,515  | 6      | 83.8                                      | 8,372   |  |  |
| 90- 99.9                         | 11              | 93.6                                      | 8,273  | 7      | 93.0                                      | 8,321   |  |  |
| 100-109.9                        | 8               | 104.6                                     | 7,927  | 2      | 104.8                                     | 13,091  |  |  |
| 110-119.9                        | 6               | 112.1                                     | 9,823  | 4      | 113.8                                     | 10,703  |  |  |
| 120-129.9                        | 9               | 125.4                                     | 9,420  | 13     | 126.3                                     | 10,108  |  |  |
| 130-139.9                        | 6               | 132.4                                     | 9,943  | 6      | 133.9                                     | 11,136  |  |  |
| 140-149.9                        | 7               | 144.4                                     | 10,104   | 5      | 144.8                                     | 13,453  |  |  |
| 150-159.9                        | 6               | 153.3                                     | 10,745   | ---    | ---                                       | ---   |  |  |
| 160-169.9                        | 1               | 168.0                                     | 11,910   | 4      | 162.8                                     | 13,955  |  |  |
| 170-179.9                        | 3               | 173.5                                     | 12,746   | 6      | 173.3                                     | 15,357  |  |  |
| 180-189.9                        | ---             | ---                                       | ---  | ---    | ---                                       | ---   |  |  |
| 190-199.9                        | 3               | 191.5                                     | 18,291   | 2      | 190.0                                     | 12,634  |  |  |
| Total or average                 | 128             | 92.9                                      | 7,876.8  | 95     | 99.8                                      | 8,765   |  |  |
| Standard error                   |                 |   | 16.49  |        |   | 18.01   |  |  |
| Standard deviation               |                 |   | 46.97  |        |   | 46.48   |  |  |
| Coefficient of correlation       |                 |   | .936   |        |   | .922  |  |  |



cultivated land, consumption of energy increased by approximately 775 horsepower hours for each 10 acres of cropland. On combination cash-crop-livestock farms for each 10 acres of cropland, average consumption of energy increased by about 865 horsepower hours. This relationship between size of farm and consumption of energy is shown graphically in figure 4.

### Rate of Power Developed by Tractors and Horses

Annual use of tractors and horses consists of a variety of loads of varying duration. The rate of energy consumption--that is, horsepower hours per tractor hour or average horsepower developed--depends primarily upon the type of work done, in other words, the load. If a tractor on a given farm is used extensively, the proportion of light work is often larger than on another farm of similar organization where the same sized tractor is used over a short period and where heavy work ordinarily would constitute the main jobs. Therefore, as the number of hours the tractor is used increases, the average horsepower developed frequently declines.

In the discussions of the method of analysis used in this study<sup>11/</sup>, and particularly in table 3 (page 20), some of the variations are shown. A 14-HP tractor actually was developing only 10 horsepower in plowing sod and 5 horsepower when used to bind grain. This illustrates the extremes of variations that may be found in field work.

Despite the many factors that cause variations in power developed, a certain value is inherent in average data of this type. The main reason for including them in these discussions is the fact that it presents a rough method of estimating the average load for power units of different sizes used on different types and sizes of farms. Unfortunately, the sample for some of the classifications used is too small to obtain data that are entirely reliable.

In table 17, average annual consumption of energy per hour of use, or horsepower developed, is given for tractors and horses by type and size of farm. On cash-crop farms, average horsepower developed is slightly larger than on specialized livestock or combination cash-crop-livestock farms of all sizes. This is true also for

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<sup>11/</sup> See pages 11 to 22.



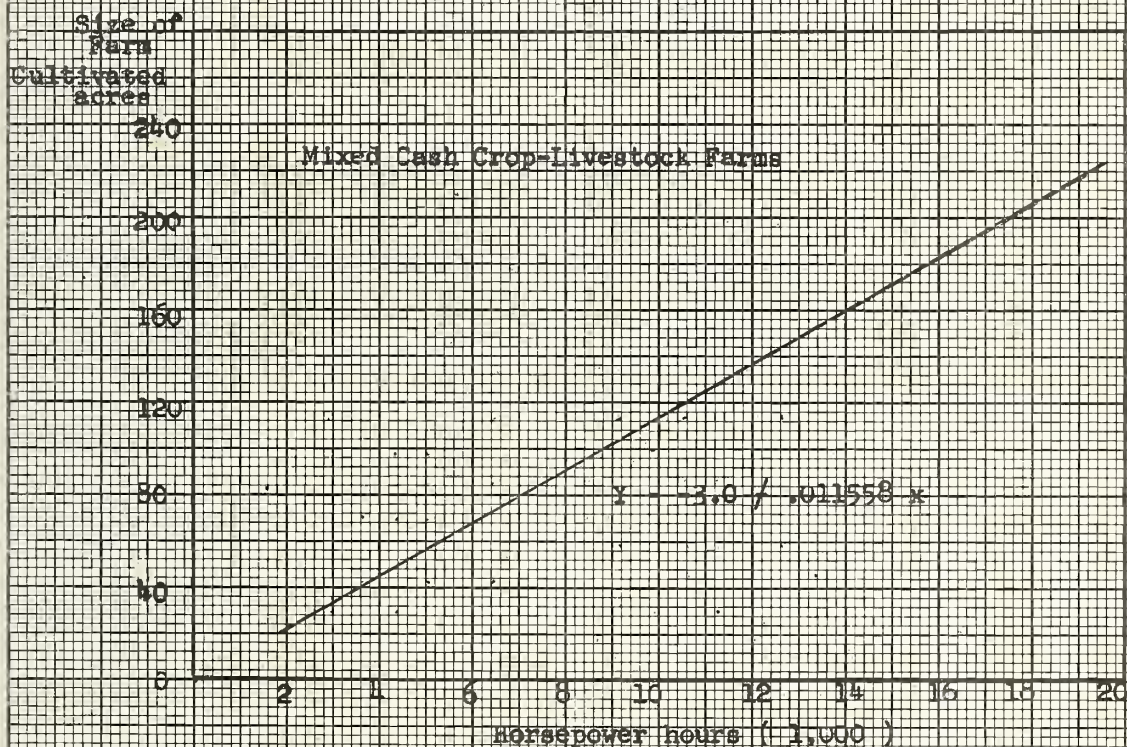
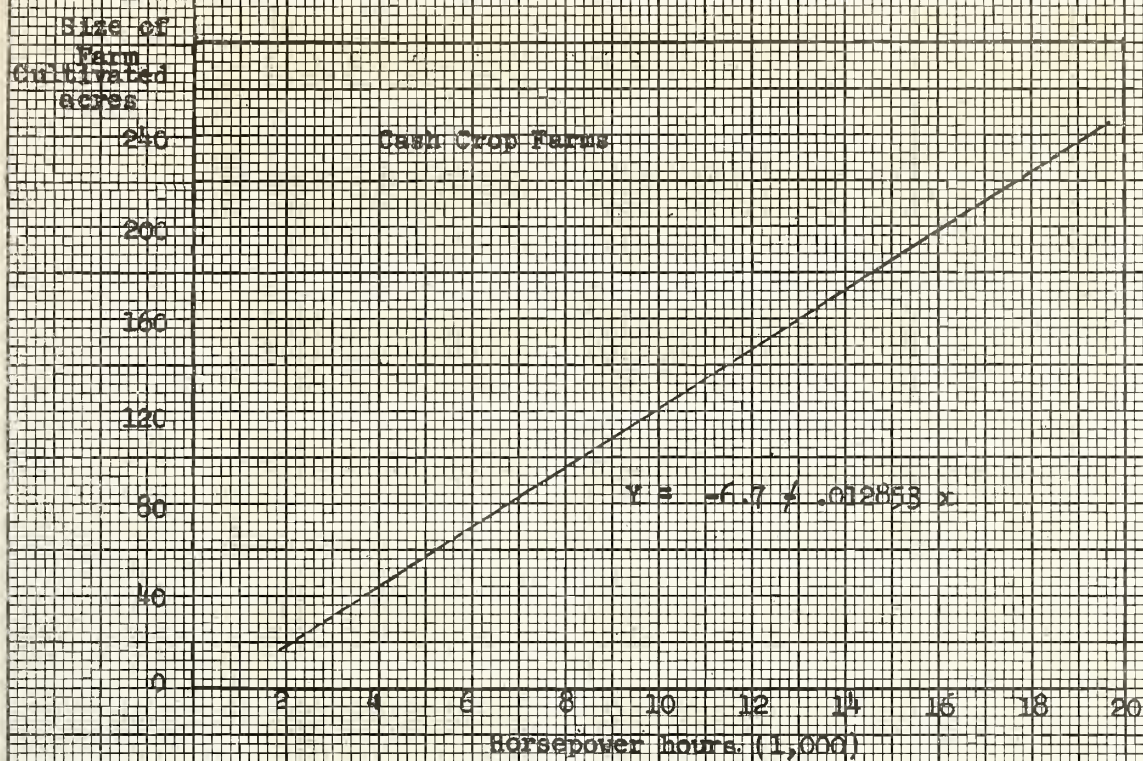


Figure 4.- Relation between size of farm and energy consumption, three major irrigated areas, southern Idaho, 1940



Table 17.- Power developed per tractor and per horse by type and size of farm, three major irrigated areas, southern Idaho, 1940

| Type and size of farm<br>(cultivated acres) | Tractors |                                    |                      |                                   |                                    | Horses                           |                      |  |      |  |
|---|----------|------------------------------------|----------------------|-----------------------------------|------------------------------------|----------------------------------|----------------------|--|------|--|
|   | Farms    | Average<br>rating<br>of<br>tractor | Total<br>use<br>1940 | Total<br>horse-<br>power<br>hours | Average<br>power<br>devel-<br>oped | Average<br>number<br>per<br>farm | Total<br>use<br>1940 | Total<br>equiv-<br>alent<br>horse-<br>power<br>developed | EHP  |  |
|   |          |                                    |                      |                                   |                                    |                                  |                      |  |      |  |
| Number                                      | DBHP     | Hours                              | HP hr.               | HP                                | Number                             | Hours                            | EHP hr.              | EHP  |      |  |
| Livestock farms                             |          |                                    |                      |                                   |                                    |                                  |                      |  |      |  |
| Under 50 acres                              | 8        | 14.27                              | 338                  | 3,303                             | 9.77                               | 2.0                              | 428                  | 862  | 2.01 |  |
| 50-74 acres                                 | 12       | 15.67                              | 350                  | 3,276                             | 9.36                               | 2.2                              | 621                  | 1,272  | 2.05 |  |
| 75-99 acres                                 | 8        | 15.43                              | 266                  | 2,732                             | 10.27                              | 3.3                              | 1,306                | 2,744  | 2.10 |  |
| 100-124 acres                               | 2        | 24.68                              | 606                  | 4,737                             | 7.82                               | 2.5                              | 586                  | 1,151  | 1.96 |  |
| 125-149 acres                               | 3        | 15.14                              | 557                  | 6,393                             | 11.48                              | 4.7                              | 2,113                | 4,483  | 2.12 |  |
| 150-199 acres                               | 2        | 14.81                              | 630                  | 6,030                             | 9.57                               | 4.5                              | 2,990                | 6,062  | 2.03 |  |
| 200 acres and over                          | 1        | 37.56                              | 412                  | 8,164                             | 19.82                              | 4.0                              | 4,665                | 10,598   | 2.27 |  |
| Total or average                            | 36       | 16.32                              | 378                  | 3,790                             | 10.03                              | 2.8                              | 1,094                | 2,295  | 2.10 |  |
| Cash-crop farms                             |          |                                    |                      |                                   |                                    |                                  |                      |  |      |  |
| Under 50 acres                              | 15       | 12.39                              | 355                  | 3,507                             | 9.88                               | 1.4                              | 579                  | 1,196  | 2.07 |  |
| 50-74 acres                                 | 42       | 14.29                              | 408                  | 4,390                             | 10.76                              | 2.6                              | 1,234                | 2,560  | 2.07 |  |
| 75-99 acres                                 | 26       | 15.50                              | 520                  | 4,556                             | 8.76                               | 3.0                              | 1,384                | 2,759  | 1.99 |  |
| 100-124 acres                               | 18       | 16.19                              | 445                  | 4,465                             | 10.03                              | 3.8                              | 1,968                | 3,792  | 1.93 |  |
| 125-149 acres                               | 20       | 15.23                              | 623                  | 6,139                             | 9.85                               | 4.0                              | 2,400                | 4,650  | 1.94 |  |
| 150-199 acres                               | 13       | 17.76                              | 731                  | 7,909                             | 10.82                              | 4.5                              | 2,462                | 4,675  | 1.90 |  |
| 200 acres and over                          | 3        | 30.06                              | 648                  | 10,436                            | 16.10                              | 7.0                              | 3,738                | 8,181  | 2.19 |  |
| Total or average                            | 137      | 15.37                              | 495                  | 5,056                             | 10.21                              | 3.2                              | 1,628                | 3,240  | 1.99 |  |
| (Continued)                                 |          |                                    |                      |                                   |                                    |                                  |                      |  |      |  |

(Continued)





farms that range from 50 to 75 acres, which is almost the only size group for which valid comparisons may be made. However, average horsepower developed on different types of farms reflects the size of power unit in addition to the extent to which the unit is utilized; that is, whether it is loaded to capacity a large proportion of the time operated. On an average of all sizes of combination cash-crop-livestock farms, the available mechanical power unit was smallest, more horses were employed to provide additional power, and the rate of energy consumption in relation to the size of power unit, was largest.

Size of power unit, in relation to average horsepower developed, was only slightly smaller on cash-crop farms. On specialized livestock farms on which the average size of power unit was relatively large, the relationship between rate of energy consumption and size of unit was lowest. In other words, the large variety of individual jobs on a farm makes it more difficult to load a large tractor to capacity than a smaller one. For many individual jobs, a small tractor more often can be loaded to capacity. A large tractor, because of investment in equipment and difficulty in handling large sizes of implements, cannot be given a full load in as many jobs. This is indicated also in the rates given for all types of farms by sizes. The average size of the power unit increases with the size of farm more rapidly than average horsepower developed. Thus, the ratio of horsepower developed to size of tractor declines.

This relationship is shown more adequately in table 18 and table 34, page 117, where average horsepower developed is presented by size groupings of tractors and extent of annual use. In these tables, only those farms were included on which a single tractor unit was used, as the combined energy consumption of two or more units of different sizes would introduce additional difficulties. Average horsepower developed increases with the size of the tractor but the ratio between the two declines.



Table 18.— Power developed by tractor based on fuel consumption on farms having one tractor, by size of power, three major irrigated areas, southern Idaho, 1940

| Size of tractor<br>(grouped by DBHP ratings) | Average |              |                   | Average                        |         | Average |    | Total                       |                   | Horsepower developed based |                              |
|--|---------|--------------|-------------------|--------------------------------|---------|---------|----|-----------------------------|-------------------|----------------------------|------------------------------|
|  | Farms   | size of farm | rating of tractor | number of hours used, all work | DBHP    | Hours   | HP | Average on fuel consumption | horse-power hours | Average                    | Percent of average DB rating |
|  |         |              |                   |                                |         |         |    |                             |                   |                            |                              |
| Under 10.00 HP                               | 59      | 85.6         | 9.50              | 492.8                          | 3,629.0 | 7.4     | 78 |                             |                   |                            |                              |
| 10.00 to 14.99                               | 98      | 84.9         | 12.31             | 427.2                          | 3,644.6 | 8.5     | 69 |                             |                   |                            |                              |
| 15.00 to 19.99                               | 82      | 111.7        | 17.39             | 478.8                          | 5,652.0 | 11.8    | 68 |                             |                   |                            |                              |
| 20.00 to 24.99                               | 18      | 125.7        | 21.80             | 402.6                          | 6,203.2 | 15.4    | 71 |                             |                   |                            |                              |
| 25.00 and over                               | 2       | 133.5        | 27.04             | 353.0                          | 5,809.8 | 16.5    | 61 |                             |                   |                            |                              |
| Total or average                             | 259     | 96.7         | 14.05             | 456.2                          | 4,471.1 | 9.8     | 70 |                             |                   |                            |                              |

## ENERGY REQUIREMENTS IN RELATION TO ENERGY CONSUMPTION AS A MEASURE OF EFFICIENCY IN THE USE OF POWER ON FARMS

Energy requirement is the amount of energy necessary to move a given implement against a specific resistance over a given distance. It is expressed in precise--that is, measurable--units. The type, size, or construction of the power unit used to perform this work is immaterial in the determination of energy requirements. That is, regardless of whether teams or tractors of different sizes, or even men, perform the work, the energy requirement to do the work remains the same.

Energy use or consumption, on the other hand, is the amount of energy employed or consumed to move a given implement. It varies with the type, size, and other characteristics of the power unit doing the work, and is expressed in units commonly employed with the particular type of power. Thus, for manual labor, we speak of man-hours; for horse work, we speak of horse-hours; for tractor, we speak of horsepower hours; and for electric motors, we speak of kilowatt-hours.

Energy requirements are calculated from the draft of an implement without regard to the type of power used, but energy use or consumption as here calculated considers type of power employed, source of energy, and efficiency of power unit in converting fuel into energy. Furthermore, the calculation of energy requirements for a particular type of work per acre, by using the draft per foot of implement, does not take into account the particular conditions under which the work is performed on fields but regards it as one continuous operation at the given pull per foot of implement. For that reason it is theoretical in nature. But in calculating energy consumption all practical operating conditions are considered which are reflected in a higher fuel consumption and lower energy output than would be required on a theoretical basis.

The draft of an implement in pounds per foot, which is necessary for the calculation of theoretical energy requirements, can be determined accurately only by means of a dynamometer. As there are variations in the draft of an implement even under

similar soil and climatic conditions<sup>12/</sup> and as it would be impossible to determine the draft for each implement on every farm, it is suggested that averages be used for all farms in a somewhat homogeneous area. Thus, the average draft of an implement is multiplied by a constant factor to obtain theoretical horsepower hour requirements per acre. The development of this factor, which amounts to 0.022, is shown in footnote 13. If, in mold-board plowing, the draft of the implement is 775 lbs. per foot, the theoretical energy requirement per acre is  $775 \times 0.022$ , or 16.94 horsepower hours per acre. If the draft of the same or another implement is 500 lbs. per foot of width, the theoretical energy requirement is 11.00 horsepower hours per acre for that work.

<sup>12/</sup> For variations in the draft of implements, see Mont. Expt. Sta. Bul. 344 entitled "A Study of the Operation of Tractors and Implements Under Farm Conditions", by Murdock, H. E. Also see Amer. Soc. of Agr. Engin., Agricultural Engineering, Data #2, Crop Machinery Use Data, compiled by C. B. Richey, June 1949.

<sup>13/</sup> Horsepower hours per acre = Horsepower x hours per acre

$$\text{Power} = \frac{\text{Pull} \times \text{Distance}}{\text{Time}} \quad \text{or} \quad \text{Pull} \times \text{Velocity}$$

P = Pull in pounds

V = Velocity in miles per hour

$$\text{Horsepower (HP)} = PV \frac{5280}{33000 \times 60} \quad \text{or} \quad \frac{V}{375} P$$

$$\text{Hours per Acre} = \frac{43560}{W V 5280}$$

W = Width of implement in feet

$$\begin{aligned} \text{Horsepower hours per acre} &= \frac{V}{375} P \times \frac{43560}{W V 5280} \\ &= \frac{43560}{375 \times 5280} \frac{P}{W} \\ &= \frac{P}{W} \times \frac{1}{45.45} \\ &= \frac{P}{W} \times .022 \end{aligned}$$

$\frac{P}{W}$  = Pull per foot of width of implement in pounds



Of greater practicable use than the theoretical energy requirements per acre are energy requirements which are possible of attainment. Even these are exceeded in most cases by farmers in their actual consumption of energy as calculated from fuel. Overlapping of implements, delays while implements are cleared of trash, turning at ends of fields, and other cases occurring more or less frequently are unavoidable and result in greater use of fuel and consequently in higher consumption of energy than are theoretically required. To adjust theoretical energy requirements so they will serve as a realistic standard in judging efficiency in the use of power on farms, it is suggested here that they be increased to a level of attainable energy requirements for each separate field operation. The adjustment proposed here is the difference between the theoretical and the actual work performed daily. The theoretical performance of work in acreage covered can be calculated from width of implement, speed of operation, and time of actual field work per day. The actual performance is reported by farmers. Most of the factors which cause reported acreage to be lower than calculated acreage are identical with those causing attainable energy requirement to be higher than theoretical energy requirement. Calculated acreage does not consider stops, overlapping, turning at ends of fields, and other unavoidable delays. Acreage actually covered by farmers would account for these practical operating conditions by a lower acreage reported than is theoretically possible. A considerable variation was found in the ratio of calculated to reported acreage for individual field operations. In plowing, there is less delay and overlapping than in harrowing. On an average, reported acreage plowed was only 10 to 15 percent lower than calculated acreage, while in harrowing it was 25 percent lower.

The method of calculating attainable energy requirements and the comparison between these requirements and energy consumption as calculated from fuel consumption is shown in table 19 for selected field operations. As no test data for the draft of implements are available, estimates of the pull per foot of implement are shown in the first column for the particular field operation. The theoretical energy requirement per acre (column 2) are these values multiplied by 0.022. Records for many individual field operations indicated that in plowing sod the reported acreage was about 88 percent of the acreage calculated. In plowing stubble it was 90 percent, for tandem disking 78 percent, and for spiketooth harrowing 75 percent.

Table 19.- Comparison of energy requirements with energy consumption for selected field operations, three major irrigated areas, southern Idaho, 1940

| Field operation           | Estimated:<br>pull<br>per foot | Theoretical:<br>energy<br>requirement:<br>per acre | Adjustment:<br>factor | Attainable:<br>energy<br>requirement:<br>per acre | Average:<br>energy<br>consumption:<br>per acre | Energy<br>consumption<br>above energy<br>requirement<br>per acre |
|---------------------------|--------------------------------|--|-----------------------|---|--|--|
|                           | Pounds                         | HP hours   |                       | HP hours  | HP hours                                       | Percent  |
| Plowing, moldboard        |                                |  |                       |   |  |  |
| Sod or alfalfa . . . .    | 775                            | 17.0   | 88                    | 19.4  | 21.7   | 11.9   |
| Stubble or row-crop       |                                |  |                       |   |  |  |
| land . . . . .            | 500                            | 11.0   | 90                    | 12.2  | 16.6   | 36.1   |
| Disking, tandem . . . .   | 120                            | 2.6  | 78                    | 3.4   | 5.1  | 50.0   |
| Harrowing, spiketooth . . | 55                             | 1.2  | 75                    | 1.6   | 2.4  | 50.0   |

More frequent stops to clear implements and more overlapping account for a lower actual performance for disking and harrowing than was calculated. These values have been entered in column 3 as the adjustment factor for the theoretical energy requirement. Thus, in adjusting 0.022 by the percentage which the reported acreage is below the calculated acreage, values are obtained which, when multiplied by the draft (column 1), result in attainable energy requirements (column 4). These may now be compared with average consumption as calculated from fuel consumption (column 5). The extent to which consumption of energy is above attainable energy requirement indicates the average efficiency in the use of tractor power on farms for the specified field operation.

For plowing sod, an operation in which power and size of implement are ordinarily fairly well matched, consumption of energy was only 12 percent higher than attainable energy requirement. In plowing stubble, the lighter load cannot be fully compensated for by greater speed of operation. The efficiency is considerably lower. For lighter field operations, such as disking and harrowing, for which power unit and implement ordinarily are not fitted so well and where overlapping and frequent stops are the rule, the efficiency in the use of tractor power is the lowest, energy consumption as calculated from fuel consumption being 50 percent higher than the attainable energy requirement.

In connection with the discussion of the influence of the combination of power and implement upon energy consumption<sup>14/</sup>, the increase in consumption of energy as the combination became less favorable was pointed out. In the case of plowing sod, consumption of energy increased from an average of 16 HP hours per acre for combinations of less than one-half rated horsepower of the tractor per inch of cut of the moldboard plow, to more than 30 HP hours per acre for combinations over one rated horsepower per inch of cut. While the combination of power and implement is not the only factor that influences energy consumption per acre, it may be noted that more than 50 percent of the combinations under 0.6 rated horsepower of the tractor per inch of cut of moldboard plow had an energy consumption that was below the attainable energy requirement as calculated above. The majority of all cases of plowing sod, however, had an energy consumption that exceeded the attainable requirement.

<sup>14/</sup> See pages 31 ff.



## SEASONAL DISTRIBUTION OF ENERGY CONSUMPTION ON A TYPICAL FARM IN THE UPPER SNAKE RIVER AREA

The size of tractor and implements that are needed to perform all necessary field operations depends upon the size of farm and its organization. Seasonal distribution of all field work to be done by the tractor, that is, the time and amount of work needed to complete the job within certain limits, is also of great importance in selecting the size of tractor. A typical cash-crop farm in the Upper Snake River Area was chosen to illustrate the seasonal distribution of the use of power. To simplify the illustration, the farm was operated with tractor power only; no horses were used. Furthermore, only the distribution of field work is given.

The farm consisted of 140 acres, of which 30 were in permanent pasture, garden, roads, ditches, farmstead, and wasteland, leaving 110 acres of cultivated land. There were 35 acres of alfalfa and 10 acres of red clover seed; 40 acres of row crops, of which 25 acres were in potatoes and 15 acres in sugar beets; and 25 acres in grain crops, of which 13 acres were in wheat and 12 acres in barley. The rotation called for a sod crop followed by row crops, which in turn were followed by grains.

Machinery for field work consisted of one 16-HP tractor, one 1-bottom 18-inch moldboard plow, one 3-section spiketooth harrow, one 10-foot land leveler, one 10-foot grain drill, one 7-foot mower, one 8-foot dump rake, one 2-row potato cultivator, one 4-row beet cultivator, one 1-row potato digger, one 1-row beet lifter, and one 6-foot binder. This equipment was of the type for use with mechanical power and represented the kind of equipment then found in the Upper Snake River Area on farms of this type and size. A threshing machine was not owned by the operator but was used cooperatively or hired. Power to operate the thresher was supplied by the farmer.

Field operations and average rates of field work for labor and power are given in table 20 by crops and individual operations. This table shows only field operations in which the tractor was used during the season. Threshing of grain is included as it generally follows soon after the binding of the crop. Threshing of clover seed is not included, as this work is usually done late in the fall or winter. Hauling, which in total requires considerable work, is also excluded as horses or trucks were used more frequently in this kind of work. In fact, many of the lighter field operations in practice and under conditions in 1940 would have been performed by horses rather than by tractors.

Table 20. Field operations and labor used in operating tractor-drawn equipment on a 140-acre cash-crop farm, Upper Snake River

| Crop and field operation   | Total acres worked | Man hours             |              | Horsepower hours      |                |
|----------------------------|--------------------|-----------------------|--------------|-----------------------|----------------|
|                            |                    | Average rate per acre | Total        | Average rate per acre | Total          |
|                            |                    |                       |              |                       |                |
|                            |                    |                       |              |                       |                |
|                            |                    | Man-hours             | Man-hours    | HP hours              | HP hours       |
| Potatoes                   |                    |                       |              |                       |                |
| Plowing . . . . .          | 25                 | 1.96                  | 49.0         | 23.1                  | 577.5          |
| Harrowing . . . . .        | 75                 | .28                   | 21.0         | 2.9                   | 217.5          |
| Leveling . . . . .         | 25                 | .33                   | 8.3          | 4.3                   | 107.5          |
| Planting . . . . .         | 25                 | <u>1/1.78</u>         | <u>44.4</u>  | <u>7.7</u>            | <u>192.5</u>   |
| Harrowing . . . . .        | 25                 | .28                   | 7.0          | 2.9                   | 72.5           |
| Cultivating . . . . .      | 125                | .49                   | 61.3         | 5.2                   | 650.0          |
| Digging . . . . .          | 25                 | <u>1/3.34</u>         | <u>83.4</u>  | <u>17.4</u>           | <u>435.0</u>   |
| Total or average . . . . . | <u>25</u>          | <u>10.98</u>          | <u>274.4</u> | <u>90.1</u>           | <u>2,252.5</u> |
| Sugar beets                |                    |                       |              |                       |                |
| Plowing . . . . .          | 15                 | 1.54                  | 23.1         | 18.2                  | 273.0          |
| Harrowing . . . . .        | 45                 | .28                   | 12.6         | 2.9                   | 130.5          |
| Leveling . . . . .         | 15                 | .33                   | 5.0          | 4.3                   | 64.5           |
| Planting . . . . .         | 15                 | <u>1/1.40</u>         | <u>21.0</u>  | <u>5.0</u>            | <u>75.0</u>    |
| Cultivating . . . . .      | 90                 | .50                   | 45.0         | 4.8                   | 432.0          |
| Lifting . . . . .          | 15                 | 2.13                  | 31.9         | 20.2                  | 303.0          |
| Total or average . . . . . | <u>15</u>          | <u>9.24</u>           | <u>138.6</u> | <u>85.2</u>           | <u>1,278.0</u> |
| Small grains               |                    |                       |              |                       |                |
| Disking . . . . .          | 25                 | .46                   | 11.5         | 4.9                   | 122.5          |
| Harrowing . . . . .        | 50                 | .28                   | 14.0         | 2.9                   | 145.0          |
| Leveling . . . . .         | 25                 | .33                   | 8.3          | 4.3                   | 107.5          |
| Drilling . . . . .         | 25                 | <u>1/1.12</u>         | <u>28.0</u>  | <u>4.0</u>            | <u>100.0</u>   |
| Corrugating . . . . .      | 25                 | .35                   | 8.7          | 3.3                   | 82.5           |
| Binding . . . . .          | 25                 | <u>1/1.28</u>         | <u>32.0</u>  | <u>7.0</u>            | <u>175.0</u>   |
| Threshing . . . . .        | 25                 | <u>1/2.60</u>         | <u>65.0</u>  | <u>12.0</u>           | <u>300.0</u>   |
| Total or average . . . . . | <u>25</u>          | <u>6.70</u>           | <u>167.5</u> | <u>41.3</u>           | <u>1,032.5</u> |
| Alfalfa hay                |                    |                       |              |                       |                |
| Springtooth . . . . .      | 35                 | .38                   | 13.3         | 5.0                   | 175.0          |
| Corrugating . . . . .      | 35                 | .35                   | 12.3         | 3.3                   | 115.5          |
| Mowing . . . . .           | 70                 | .41                   | 28.7         | 4.5                   | 315.0          |
| Raking . . . . .           | 70                 | .40                   | 28.0         | 3.5                   | 245.0          |
| Bunching . . . . .         | 70                 | .30                   | 21.0         | 2.5                   | 175.0          |
| Total or average . . . . . | <u>35</u>          | <u>2.95</u>           | <u>103.3</u> | <u>29.3</u>           | <u>1,025.5</u> |
| Red clover seed            |                    |                       |              |                       |                |
| Fertilizing . . . . .      | 10                 | .50                   | 5.0          | 3.5                   | 35.0           |
| Corrugating . . . . .      | 10                 | .35                   | 3.5          | 3.3                   | 33.0           |
| Mowing . . . . .           | 20                 | .41                   | 8.2          | 4.5                   | 90.0           |
| Raking . . . . .           | 20                 | .40                   | 8.0          | 3.5                   | 70.0           |
| Bunching . . . . .         | 20                 | .30                   | 6.0          | 2.5                   | 50.0           |
| Total or average . . . . . | <u>10</u>          | <u>3.07</u>           | <u>30.7</u>  | <u>27.8</u>           | <u>278.0</u>   |
| All field operations       | 110                | 6.50                  | 714.5        | 53.3                  | 5,866.5        |

1/ Two men required or supplied by farmer.



Somewhat more than 600 hours of tractor work would be required with a total of nearly 5,900 horsepower hours. In the operation of power for field work, somewhat more than 700 man-hours would be needed. Production of potatoes under the assumed conditions required the largest number of horsepower hours, followed by sugar beets, grains, hay, and forage seeds. Approximately 30 percent of the total horsepower hours would be used in preparing the land. Planting required 6 percent, cultivation of crops 27 percent, and harvesting 37 percent. Thus, harvesting operations have a higher total consumption of energy than land preparation, which usually is considered the main power load. However, the power load for preparation of land was significant because of the time limit. All land-preparation work, or 30 percent of the total horsepower hours used for all field work on this farm, fell within 8 weeks and much of it was carried on while planting and cultivating operations were under way. Harvesting operations from the first hay crop to the sugar-beet harvest extended over a period of 15 weeks and constituted a relatively small load in any one week.

Consumption of energy during the season, by major groups of field operations, is given in table 21 and shown graphically in figure 5. Field work begins normally during the last week in March when the sugar-beet field is plowed. Preparation of the land for grains and potatoes follows quickly. While this work goes on, sugar beets and grains are planted, but planting of potatoes ordinarily is delayed until all danger from late frosts has passed. Crop cultivation begins at the end of April or the beginning of May. At that time of the season, grain fields must be corrugated and sugar beets cultivated or prepared for irrigation. Cultivating continues on the row-crop fields until the beginning of August. Harvesting starts with the cutting of the first hay crop at the end of June and early July, and continues until the first week in November, when the beet harvest is completed.

Weather interference can be expected almost any time in the spring or fall when the work load is heaviest. The desirability of reserve power in the form of a team of horses is readily understood. In the spring it would permit relieving the tractor of such jobs as harrowing and planting; in the fall hauling jobs would fully use this reserve power.

Tractor field work, as illustrated, occurs in waves of declining peaks. This is caused by the fact that field work must be done in certain periods to obtain best results. On the other hand, the slack periods for the tractor are not periods of leisure for the farmer and his workers. Among the many jobs for which no power is used, irrigating of crops is the most important.



Table 21.- Seasonal distribution of the use of tractor power on a 140-acre cash-crop farm, Upper Snake River Area, Idaho, by major types of field operation

| Month and week   |             | Land<br>: prepara-<br>: tion | Plant-<br>: ing | Crop<br>: culti-<br>: vation | Harv-<br>: esting | Total all<br>: opera-<br>: tions |
|------------------|-------------|------------------------------|-----------------|------------------------------|-------------------|----------------------------------|
|                  |             | HP hr.                       | HP hr.          | HP hr.                       | HP hr.            | HP hr.                           |
| March,           | 4th . . . . | 220                          | ---             | ---                          | ---               | 220                              |
| April,           | 1st . . . . | 305                          | ---             | ---                          | ---               | 305                              |
|                  | 2nd . . . . | 319                          | 30              | ---                          | ---               | 349                              |
|                  | 3rd . . . . | 249                          | 110             | ---                          | ---               | 359                              |
|                  | 4th . . . . | 280                          | 35              | 35                           | ---               | 350                              |
| May,             | 1st . . . . | 216                          | ---             | 116                          | ---               | 332                              |
|                  | 2nd . . . . | 123                          | ---             | 162                          | ---               | 285                              |
|                  | 3rd . . . . | 33                           | 80              | 157                          | ---               | 270                              |
|                  | 4th . . . . | ---                          | 113             | 116                          | ---               | 229                              |
| June,            | 1st . . . . | ---                          | ---             | 145                          | ---               | 145                              |
|                  | 2nd . . . . | ---                          | ---             | 130                          | ---               | 130                              |
|                  | 3rd . . . . | ---                          | ---             | 202                          | ---               | 202                              |
|                  | 4th . . . . | ---                          | ---             | 110                          | 220               | 330                              |
| July,            | 1st . . . . | ---                          | ---             | 91                           | 228               | 319                              |
|                  | 2nd . . . . | ---                          | ---             | 130                          | 25                | 155                              |
|                  | 3rd . . . . | ---                          | ---             | 72                           | ---               | 72                               |
|                  | 4th . . . . | ---                          | ---             | 100                          | ---               | 100                              |
| August,          | 1st . . . . | ---                          | ---             | 30                           | 150               | 180                              |
|                  | 2nd . . . . | ---                          | ---             | ---                          | 210               | 210                              |
|                  | 3rd . . . . | ---                          | ---             | ---                          | 198               | 198                              |
|                  | 4th . . . . | ---                          | ---             | ---                          | 90                | 90                               |
| September,       | 1st . . . . | ---                          | ---             | ---                          | 140               | 140                              |
|                  | 2nd . . . . | ---                          | ---             | ---                          | 160               | 160                              |
|                  | 3rd . . . . | ---                          | ---             | ---                          | 199               | 199                              |
|                  | 4th . . . . | ---                          | ---             | ---                          | 190               | 190                              |
| October,         | 1st . . . . | ---                          | ---             | ---                          | 45                | 45                               |
|                  | 2nd . . . . | ---                          | ---             | ---                          | ---               | ---                              |
|                  | 3rd . . . . | ---                          | ---             | ---                          | 100               | 100                              |
|                  | 4th . . . . | ---                          | ---             | ---                          | 120               | 120                              |
| November,        | 1st . . . . | ---                          | ---             | ---                          | 83                | 83                               |
|                  | 2nd . . . . | ---                          | ---             | ---                          | ---               | ---                              |
| Total . . . . .  |             | 1,745                        | 368             | 1,596                        | 2,158             | 5,867                            |
| Percent of total |             | 29.7                         | 6.3             | 27.2                         | 36.8              | 100.0                            |



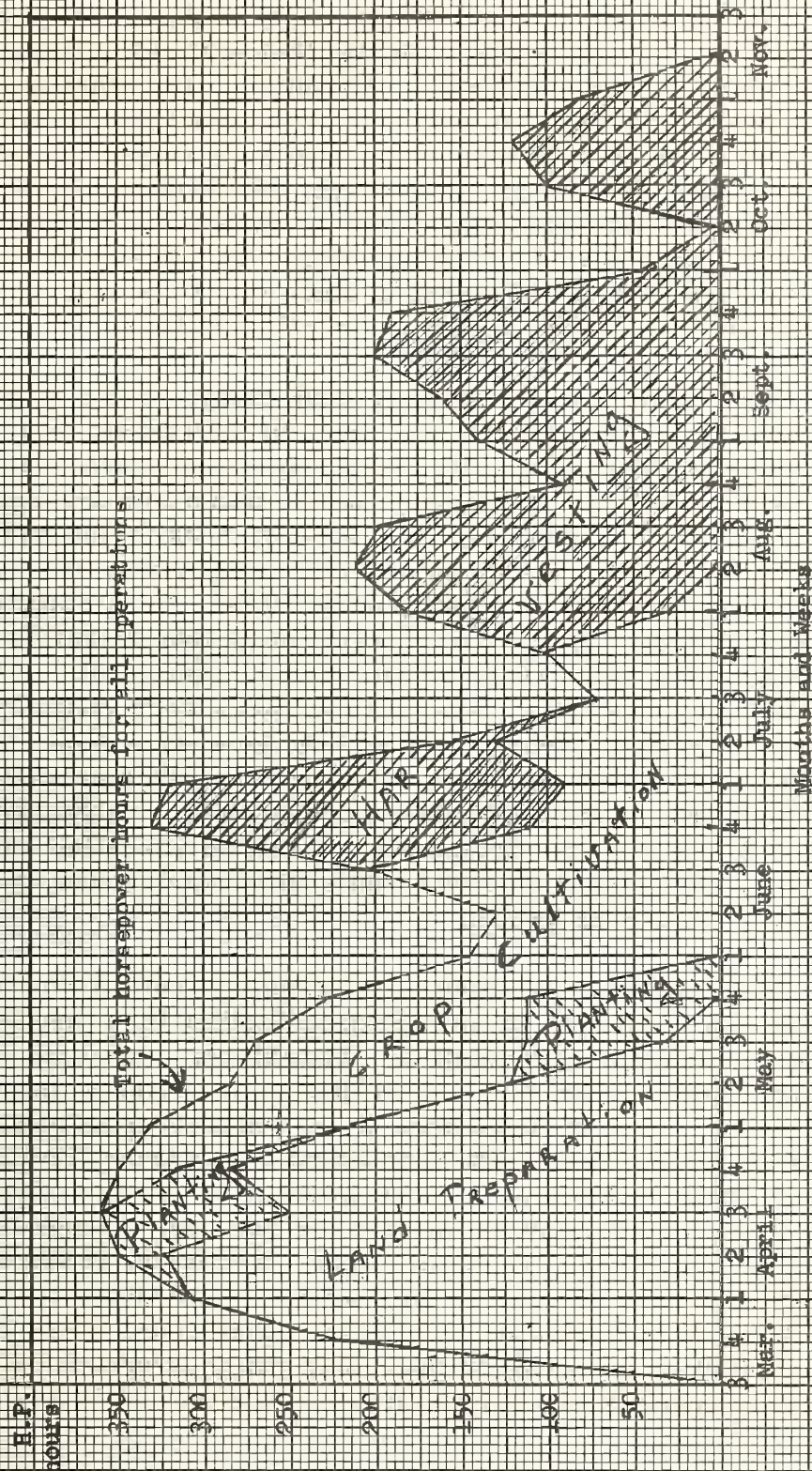


Figure 5. Seasonal distribution of the use of tractor power on a 140-acre cash-crop farm, Upper Snake River area, Southern Idaho, by major types of field operations.



## INVESTMENT IN POWER AND EQUIPMENT

The primary purpose of this study of the use of power on farms was to obtain physical data that will aid in using mechanical power more efficiently. Although major changes in prices and price relationships have occurred since the basic data for this study were obtained, some monetary values are useful partly for purposes of comparison, and partly to present important relationships that cannot be shown in any other way. Values obtained in 1940 can no longer be a guide but they can be used to illustrate increases since that time and, as is done in these discussions, to point out relationships.

Total investment in power, equipment, shops, and housing amounted to about \$2,600 per farm in 1940 (table 22). Investments varied considerably among types and sizes of farms. In general, specialized livestock farms had a low average investment while combination cash-crop-livestock farms had a relatively high investment in power and equipment. The reasons for this variation are readily understood. Less apparent, however, are the reasons for differences in investment by types of farms of the same size, or for various size groups of farms within the same type. These differences were caused by the particular farm organization and the amount of power and equipment needed for given enterprises. Mechanization of agricultural production has not progressed equally far in all lines of agricultural production. Even on so-called cash-crop farms, the amount of power and equipment depends upon the type of cash-crop grown.

Mechanization of potato production in southern Idaho in 1940, for example, had progressed farther than mechanization of sugar-beet production. Therefore, cash-crop farms in the Upper Snake River Area that grow potatoes would, under otherwise similar conditions, have a higher investment in power and equipment than cash-crop farms of the same size in the Twin Falls-Minidoka Area that grow sugar beets. Furthermore, the power and equipment needed for one crop may be more expensive than those for other crops. Similarly, if the predominant livestock enterprise on so-called livestock farms consisted of dairy or intensive beef-fattening operations, these farms had much higher investments than when range livestock enterprises were connected with irrigated farms and the cultivated land used



Table 22.- Average investment in power and equipment in relation to type and size of farm and power available for field work, three major irrigated areas, southern Idaho, 1940

| Type and size of farm (Cultivated acres) | Average: |       |       | Average investment in power and equipment |        |       | Total: |      |         |
|--|----------|-------|-------|---|--------|-------|--------|------|---------|
|  | No.      | Acres | Power | Tractor                                   | Horses | Truck | Auto-  | Shop | Invest. |
|  |          |       |       |   |        |       |        |      |         |
| Livestock farms                          |          |       |       |   |        |       |        |      |         |
| Under 50 acres                           | 8        | 30.2  | 18.29 | 454                                       | 109    | 3     | 196    | 178  | 1,577   |
| 50-74 acres                              | 12       | 62.0  | 20.18 | 650                                       | 155    | 132   | 119    | 296  | 2,133   |
| 75-99 acres                              | 8        | 87.4  | 22.37 | 606                                       | 188    | 22    | 162    | 462  | 2,253   |
| 100-124 acres                            | 2        | 114.5 | 29.59 | 813                                       | 185    | 300   | ---    | 448  | 3,923   |
| 125-149 acres                            | 3        | 141.7 | 25.11 | 767                                       | 268    | ---   | 115    | 858  | 3,018   |
| 150-199 acres                            | 2        | 172.0 | 23.94 | 675                                       | 252    | 550   | 175    | 50   | 2,715   |
| 200 and over                             | 1        | 220.0 | 46.65 | 600                                       | 200    | 125   | 50     | 50   | 2,651   |
| Total or average                         | 36       | 80.7  | 22.18 | 615                                       | 170    | 100   | 140    | 342  | 2,256   |
| Percentage of total                      |          |       |       | 27.3                                      | 7.5    | 4.4   | 6.2    | 15.2 | 100.0   |
| Cash-crop farms                          |          |       |       |   |        |       |        |      |         |
| Under 50 acres                           | 15       | 37.8  | 15.28 | 464                                       | 109    | 59    | 128    | 336  | 1,855   |
| 50-74 acres                              | 42       | 64.6  | 19.69 | 530                                       | 168    | 130   | 135    | 321  | 2,276   |
| 75-99 acres                              | 26       | 84.9  | 21.48 | 611                                       | 222    | 129   | 228    | 269  | 2,696   |
| 100-124 acres                            | 18       | 111.2 | 23.51 | 544                                       | 255    | 178   | 250    | 298  | 2,891   |
| 125-149 acres                            | 20       | 136.0 | 22.98 | 606                                       | 280    | 148   | 135    | 141  | 2,634   |
| 150-199 acres                            | 13       | 167.9 | 26.31 | 636                                       | 398    | 405   | 142    | 212  | 3,459   |
| 200 and over                             | 3        | 240.3 | 45.38 | 650                                       | 550    | 583   | 400    | 82   | 4,219   |
| Total or average                         | 137      | 95.7  | 21.73 | 563                                       | 229    | 167   | 174    | 268  | 2,597   |
| Percentage of total                      |          |       |       | 21.7                                      | 8.8    | 6.4   | 6.7    | 10.3 | 100.0   |

(Continued)

Table 22.- Average investment in power and equipment in relation to type and size of farm and power available for field work, three major irrigated areas, southern Idaho, 1940 (Continued)

| Type and size of farm<br>(Cultivated acres) | No. | Average: Acres | Farms: acres : avail.   | Tractor: Horses | Truck            | Auto-: mobile | Farm : equip. | Shop : equip. | Total : invest. | Total : power | per : avail. | horse        | power |
|---|-----|----------------|---|-----------------|------------------|---------------|---------------|---------------|-----------------|---------------|--------------|--------------|-------|
|   |     |                | for field:  |                 | :(farm : share): |               |               |               |                 |               | per : cult.  | acre : power |       |
|   |     |                | Dollars:Dollars:Dollars:Dollars:Dollars:Dollars:Dollars:Dollars:Dollars:Dollars:Dollars:Dollars:Dollars:Dollars |                 |                  |               |               |               |                 |               |              |              |       |
| fixed cash-crop-                            |     |                |   |                 |                  |               |               |               |                 |               |              |              |       |
| livestock farms                             |     |                |   |                 |                  |               |               |               |                 |               |              |              |       |
| Under 50 acres                              | 8   | 41.7           | 13.93   | 466             | 56               | 144           | 134           | 772           | 125             | 1,697         | 40.70        | 121.82       |       |
| 50-74 acres                                 | 29  | 64.0           | 16.21   | 466             | 124              | 165           | 199           | 800           | 263             | 2,017         | 31.52        | 124.43       |       |
| 75-99 acres                                 | 16  | 86.4           | 20.86   | 514             | 235              | 182           | 208           | 1,130         | 170             | 2,439         | 28.23        | 116.92       |       |
| 100-124 acres                               | 9   | 114.8          | 21.14   | 527             | 277              | 151           | 124           | 1,189         | 198             | 2,466         | 21.48        | 116.65       |       |
| 125-149 acres                               | 21  | 133.4          | 24.88   | 552             | 285              | 255           | 203           | 1,446         | 283             | 3,024         | 22.67        | 121.55       |       |
| 150-199 acres                               | 12  | 172.6          | 31.76   | 730             | 511              | 260           | 293           | 1,714         | 477             | 3,985         | 23.09        | 125.47       |       |
| 200 and over                                | 9   | 240.4          | 30.89   | 619             | 482              | 841           | 315           | 2,079         | 468             | 4,804         | 19.98        | 155.52       |       |
| Total or average                            | 104 | 111.9          | 22.09   | 540             | 257              | 252           | 211           | 1,229         | 279             | 2,768         | 24.74        | 125.31       |       |
| Percentage of :                             |     |                |   |                 |                  |               |               |               |                 |               |              |              |       |
| total                                       |     |                |   | 19.5            | 9.3              | 9.1           | 7.6           | 44.4          | 10.1            | 100.0         |              |              |       |
| total all farms                             |     |                |   |                 |                  |               |               |               |                 |               |              |              |       |
| Under 50 acres                              | 31  | 36.8           | 15.75   | 462             | 95               | 66            | 147           | 731           | 241             | 1,742         | 47.34        | 110.60       |       |
| 50-74 acres                                 | 83  | 64.0           | 18.61   | 525             | 151              | 142           | 155           | 895           | 297             | 2,165         | 33.83        | 116.34       |       |
| 75-99 acres                                 | 50  | 85.8           | 21.47   | 579             | 221              | 129           | 211           | 1,135         | 268             | 2,543         | 29.64        | 118.44       |       |
| 100-124 acres                               | 29  | 112.6          | 23.20   | 557             | 257              | 178           | 194           | 1,367         | 277             | 2,830         | 25.13        | 121.98       |       |
| 125-149 acres                               | 44  | 135.1          | 24.02   | 591             | 282              | 189           | 166           | 1,361         | 257             | 2,846         | 21.07        | 118.48       |       |
| 150-199 acres                               | 27  | 170.3          | 28.61   | 681             | 438              | 351           | 211           | 1,639         | 318             | 3,638         | 21.36        | 127.16       |       |
| 200 and over                                | 13  | 238.8          | 35.50   | 625             | 476              | 727           | 314           | 2,016         | 346             | 4,504         | 18.86        | 126.87       |       |
| Total or average                            | 277 | 99.8           | 21.93   | 562             | 232              | 190           | 183           | 1,168         | 282             | 2,617         | 26.22        | 119.33       |       |
| Percentage of :                             |     |                |   |                 |                  |               |               |               |                 |               |              |              |       |
| total                                       |     |                |   | 21.5            | 8.9              | 7.2           | 7.0           | 44.6          | 10.8            | 100.0         |              |              |       |



primarily for forage production. In terms of cultivated land, small livestock farms had a relatively high investment in power and equipment because dairying was the most common enterprise. On large livestock farms, the investment was relatively low because beef and sheep enterprises predominated.

On the average of all farms, the investment in power and equipment amounted to about \$26 per acre of cultivated land. It declined rapidly as the size of farm, as measured by cultivated acres, increased. On farms that averaged nearly 240 acres, the investment per acre was only 40 percent of that on small farms, which averaged 37 acres per farm.

A gradual rise as size of farm increases is shown if investment in power and equipment is related to available power for field work. Available power did not increase in the same proportion as total investment and size of farm or, in other words, the investment value per available horsepower was greater on large than on small farms. Although investment in tractors and horses per unit of rated power was lower on large than on small farms, investment in trucks and farm machinery for field work other than power was considerably higher.

The value of field power represented more than 30 percent of total investment, trucks and automobiles 14 percent, farm equipment including electric motors 45 percent, and shop equipment and machinery housing 11 percent. On specialized livestock farms, investment in power is relatively high, while on cash-crop farms investment in farm equipment is relatively more important.

### COSTS OF OPERATING FARM POWER

Data relating to cost of operating farm power in 1940 are given here not because their level is particularly significant at present, but to illustrate the relative importance of various cost items for tractors and horses.

Table 23 gives average annual costs of operating tractors and horses by type and size of farm. For tractors, variable costs, or those cost items that change almost in proportion to use, accounted for more than 50 percent of total costs on the average of all farms. This percentage increased as the size of farm increased. For horses, all cost items were relatively stable; that is, only minor

changes were connected with use. Feed costs and chore labor combined constituted by far the major part of total costs. On irrigated farms feed costs were relatively low because the feed consisted chiefly of pasture or range that would be utilized incompletely or not at all if no horses were kept. Where horses were extensively used, however, harvested feeds, especially grains, were necessary at least during the period of field work. An indication of the extent of feeding horses with harvested feeds is given by the relatively high proportion of feed costs on cash-crop and mixed cash-crop-livestock farms where there was only a little grazing land.

The average annual use of tractors on specialized livestock farms was relatively low. Average annual costs of operating tractors on these farms were also lower than on the other types. But total costs per hour of use exceeded those for other types. Tractors were used more extensively on mixed cash-crop-livestock farms and operating costs per hour of use were lowest. This relationship between extent of use of tractors and operating costs per hour by types of farms is given in table 24.

For horses, the same general relationship between use and costs per hour of use holds true. The decline in operating costs per hour accompanying an increase in use is of minor significance, however, as costs of keeping horses are relatively stable.

It has been pointed out that hours of use are poor measures of the amount of work that has been or can be accomplished. Consequently, the calculation of costs per hour of use does not give a true picture of what it costs to perform a given amount of work. Obviously, an hour of plowing costs more than an hour of harrowing or drilling grain, so far as operation of power is concerned. Consumption of energy expressed in terms of horsepower hours, on the other hand, gives the amount of energy actually expended in each operation. Costs calculated on this basis reflect actual expenditures for each operation. Thus, if a given tractor uses 10 HP hours per hour of plowing and 5 HP hours per hour of binding grain and the operating costs amount to 7 cents per HP hour, one hour of plowing, using this tractor, costs 70 cents and one hour of binding grain costs 35 cents, considering power operating costs only. In table 24, tractor and horse operating costs per horsepower hour, as well as combined costs of operating available power<sup>1</sup> by type and size of farm, are given. The significant points



Table 23.- Average annual power operating costs per farm by type and size of farm, three major irrigated areas, southern Idaho, 1940

| Type and size of farm<br>(cultivated acres) | Tractors |          |                       |                           |                             |                                       |                                   |                          |                        |          |  |  |  |
|---|----------|----------|-----------------------|---------------------------|-----------------------------|---------------------------------------|-----------------------------------|--------------------------|------------------------|----------|--|--|--|
|   | Farms:   | Fuel:    | Lub-<br>ri-<br>cants: | Repairs:<br>and<br>parts: | Total<br>variable<br>costs: | Depreciation<br>and<br>inter-<br>est: | Taxes,<br>insur.,<br>and<br>misc. | Total<br>fixed<br>costs: | Total<br>all<br>costs: | Total    |  |  |  |
|   | No.:     | Dollars: | Dollars:              | Dollars:                  | Dollars:                    | Dollars:                              | Dollars:                          | Dollars:                 | Dollars:               | Dollars: |  |  |  |
| <b>Livestock farms</b>                      |          |          |                       |                           |                             |                                       |                                   |                          |                        |          |  |  |  |
| Under 50 acres . . . . .                    | 8 :      | 85 :     | 7 :                   | 12 :                      | 104 :                       | 117 :                                 | 10 :                              | 3 :                      | 130 :                  | 234 :    |  |  |  |
| 50-74 acres . . . . .                       | 12 :     | 81 :     | 11 :                  | 19 :                      | 111 :                       | 123 :                                 | 13 :                              | 2 :                      | 138 :                  | 249 :    |  |  |  |
| 75-99 acres . . . . .                       | 8 :      | 59 :     | 12 :                  | 17 :                      | 88 :                        | 148 :                                 | 14 :                              | 2 :                      | 164 :                  | 252 :    |  |  |  |
| 100-124 acres . . . . .                     | 2 :      | 225 :    | 23 :                  | 190 :                     | 438 :                       | 168 :                                 | 17 :                              | 7 :                      | 192 :                  | 630 :    |  |  |  |
| 125-149 acres . . . . .                     | 3 :      | 96 :     | 14 :                  | 14 :                      | 124 :                       | 158 :                                 | 17 :                              | 5 :                      | 180 :                  | 304 :    |  |  |  |
| 150-199 acres . . . . .                     | 2 :      | 201 :    | 13 :                  | 5 :                       | 219 :                       | 147 :                                 | 15 :                              | -- :                     | 162 :                  | 381 :    |  |  |  |
| 200 acres and over . . . . .                | 1 :      | 240 :    | 31 :                  | 46 :                      | 317 :                       | 229 :                                 | 25 :                              | -- :                     | 254 :                  | 571 :    |  |  |  |
| Total or average . . . . .                  | 36 :     | 97 :     | 12 :                  | 26 :                      | 135 :                       | 137 :                                 | 14 :                              | 2 :                      | 153 :                  | 288 :    |  |  |  |
| Percentage of total . . . . .               |          | 33.7 :   | 4.2 :                 | 9.0 :                     | 46.9 :                      | 47.5 :                                | 4.9 :                             | .7 :                     | 53.1 :                 | 100.0 :  |  |  |  |
| <b>Cash-crop farms</b>                      |          |          |                       |                           |                             |                                       |                                   |                          |                        |          |  |  |  |
| Under 50 acres . . . . .                    | 15 :     | 116 :    | 9 :                   | 14 :                      | 139 :                       | 101 :                                 | 10 :                              | 1 :                      | 112 :                  | 251 :    |  |  |  |
| 50-74 acres . . . . .                       | 42 :     | 113 :    | 13 :                  | 10 :                      | 136 :                       | 135 :                                 | 11 :                              | 3 :                      | 149 :                  | 285 :    |  |  |  |
| 75-99 acres . . . . .                       | 26 :     | 129 :    | 15 :                  | 24 :                      | 168 :                       | 135 :                                 | 13 :                              | 3 :                      | 151 :                  | 319 :    |  |  |  |
| 100-124 acres . . . . .                     | 18 :     | 141 :    | 18 :                  | 19 :                      | 178 :                       | 179 :                                 | 15 :                              | 2 :                      | 196 :                  | 374 :    |  |  |  |
| 125-149 acres . . . . .                     | 20 :     | 198 :    | 20 :                  | 36 :                      | 254 :                       | 158 :                                 | 15 :                              | 1 :                      | 174 :                  | 428 :    |  |  |  |
| 150-199 acres . . . . .                     | 13 :     | 224 :    | 23 :                  | 32 :                      | 279 :                       | 163 :                                 | 18 :                              | 2 :                      | 183 :                  | 462 :    |  |  |  |
| 200 acres and over . . . . .                | 3 :      | 348 :    | 26 :                  | 110 :                     | 484 :                       | 152 :                                 | 20 :                              | 1 :                      | 173 :                  | 657 :    |  |  |  |
| Total or average . . . . .                  | 137 :    | 148 :    | 16 :                  | 22 :                      | 186 :                       | 143 :                                 | 13 :                              | 3 :                      | 159 :                  | 345 :    |  |  |  |
| Percentage of total . . . . .               |          | 42.9 :   | 4.6 :                 | 6.4 :                     | 53.9 :                      | 41.4 :                                | 3.8 :                             | .9 :                     | 46.1 :                 | 100.0 :  |  |  |  |

(Continued)

Table 23.- Average annual power operating costs per farm by type and size of farm, three major irrigated areas, southern Idaho, 1940 (Continued)

| Type and size of farm<br>(cultivated acres) | Farms  | Horses  |                |  |  |         | Total<br>all<br>costs |
|---|--------|---------|----------------|--|--|---------|-----------------------|
|   |        | Feed    | Chore<br>labor | Vet.,<br>shoeing,<br>barn<br>equip.,<br>etc. | Deprec-<br>iation,<br>inter-<br>est,<br>etc. | Dollars |                       |
|   | Number | Dollars | Dollars        | Dollars                                      | Dollars                                      | Dollars |                       |
| Livestock farms                             |        |         |                |  |  |         |                       |
| Under 50 acres                              | 8      | 48      | 10             | 11   | 12   | 81      |                       |
| 50-74 acres                                 | 12     | 58      | 19             | 41   | 24   | 142     |                       |
| 75-99 acres                                 | 8      | 83      | 15             | 17   | 28   | 143     |                       |
| 100-124 acres                               | 2      | 48      | 11             | 2  | 29   | 90      |                       |
| 125-149 acres                               | 3      | 163     | 37             | 63   | 30   | 293     |                       |
| 150-199 acres                               | 2      | 65      | 42             | 59   | 14   | 180     |                       |
| 200 acres and over                          | 1      | 192     | 38             | 26   | 24   | 280     |                       |
| Total or average                            | 36     | 74      | 19             | 29   | 22   | 144     |                       |
| Percentage of total                         |        | 51.4    | 13.2           | 20.1   | 15.3   | 100.0   |                       |
| Cash-crop farms                             |        |         |                |  |  |         |                       |
| Under 50 acres                              | 15     | 48      | 16             | 4  | 11   | 79      |                       |
| 50-74 acres                                 | 42     | 103     | 21             | 17   | 21   | 162     |                       |
| 75-99 acres                                 | 26     | 113     | 24             | 24   | 24   | 185     |                       |
| 100-124 acres                               | 18     | 151     | 26             | 12   | 38   | 227     |                       |
| 125-149 acres                               | 20     | 156     | 27             | 20   | 33   | 236     |                       |
| 150-199 acres                               | 13     | 184     | 26             | 12   | 43   | 265     |                       |
| 200 acres and over                          | 3      | 302     | 33             | 57   | 33   | 426     |                       |
| Total or average                            | 137    | 125     | 23             | 17   | 27   | 192     |                       |
| Percentage of total                         |        | 65.1    | 12.0           | 8.8  | 14.1   | 100.0   |                       |
| (Continued)                                 |        |         |                |  |  |         |                       |

(Continued)



Table 23.- Average annual power operating costs per farm, by type and size of farm, three major irrigated areas, southern Idaho, 1940 (Continued)

| Type and size of farm<br>(cultivated acres) | Tractors |           |           |           |           |           |           |           |           |           | Total : Total |
|---|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|---------------|
|   | Farms :  | Fuel :    | Lub- :    | Repairs : | Total :   | Deprec- : | Taxes :   | insur. :  | Housing : | fixed :   | costs :       |
|   | No. :    | Dollars : | Dollars : | Dollars : | Dollars : | Dollars : | Dollars : | Dollars : | Dollars : | Dollars : | Dollars :     |
| Mixed cash-crop-livestock farms             |          |           |           |           |           |           |           |           |           |           |               |
| Under 50 acres . . . . .                    | 8 :      | 53 :      | 8 :       | 7 :       | 68 :      | 97 :      | 8 :       |           | 3 :       | 108 :     | 176 :         |
| 50-74 acres . . . . .                       | 29 :     | 81 :      | 12 :      | 16 :      | 109 :     | 110 :     | 8 :       |           | 3 :       | 121 :     | 230 :         |
| 75-99 acres . . . . .                       | 16 :     | 133 :     | 12 :      | 33 :      | 178 :     | 134 :     | 11 :      |           | 2 :       | 147 :     | 325 :         |
| 100-124 acres . . . . .                     | 9 :      | 140 :     | 14 :      | 8 :       | 162 :     | 148 :     | 13 :      |           | 2 :       | 163 :     | 325 :         |
| 125-149 acres . . . . .                     | 21 :     | 159 :     | 18 :      | 17 :      | 194 :     | 163 :     | 12 :      |           | 4 :       | 179 :     | 373 :         |
| 150-199 acres . . . . .                     | 12 :     | 265 :     | 21 :      | 33 :      | 319 :     | 170 :     | 17 :      |           | 3 :       | 190 :     | 509 :         |
| 200 acres and over . . . . .                | 9 :      | 257 :     | 16 :      | 95 :      | 368 :     | 185 :     | 19 :      |           | 3 :       | 207 :     | 575 :         |
| Total or average . . . . .                  | 104 :    | 144 :     | 15 :      | 28 :      | 185 :     | 140 :     | 12 :      |           | 3 :       | 155 :     | 340 :         |
| Percentage of total . . . . .               |          | 42.4 :    | 4.4 :     | 7.6 :     | 54.4 :    | 41.2 :    | 3.5 :     |           | .9 :      | 45.6 :    | 100.0 :       |
| Total all farms                             |          |           |           |           |           |           |           |           |           |           |               |
| Under 50 acres . . . . .                    | 31 :     | 92 :      | 8 :       | 12 :      | 112 :     | 104 :     | 9 :       |           | 2 :       | 115 :     | 227 :         |
| 50-74 acres . . . . .                       | 83 :     | 97 :      | 12 :      | 14 :      | 123 :     | 124 :     | 11 :      |           | 3 :       | 138 :     | 261 :         |
| 75-99 acres . . . . .                       | 50 :     | 119 :     | 14 :      | 26 :      | 159 :     | 137 :     | 12 :      |           | 2 :       | 151 :     | 310 :         |
| 100-124 acres . . . . .                     | 29 :     | 146 :     | 17 :      | 28 :      | 191 :     | 169 :     | 14 :      |           | 2 :       | 185 :     | 376 :         |
| 125-149 acres . . . . .                     | 44 :     | 172 :     | 18 :      | 26 :      | 216 :     | 160 :     | 14 :      |           | 3 :       | 177 :     | 393 :         |
| 150-199 acres . . . . .                     | 27 :     | 241 :     | 21 :      | 30 :      | 292 :     | 165 :     | 17 :      |           | 3 :       | 185 :     | 477 :         |
| 200 acres and over . . . . .                | 13 :     | 277 :     | 19 :      | 95 :      | 391 :     | 180 :     | 20 :      |           | 2 :       | 202 :     | 593 :         |
| Total or average . . . . .                  | 277 :    | 140 :     | 15 :      | 24 :      | 179 :     | 141 :     | 13 :      |           | 3 :       | 157 :     | 336 :         |
| Percentage of total . . . . .               |          | 41.7 :    | 4.5 :     | 7.1 :     | 53.3 :    | 42.0 :    | 3.8 :     |           | .9 :      | 46.7 :    | 100.0 :       |

(Continued)

Table 23.- Average annual power operating costs per farm, by type and size of farm, three major irrigated areas, southern Idaho, 1940 (Continued)

| Type and size of farm<br>(cultivated acres) | Farms  | Horses  |                                     |         | Chore<br>labor | Vet.,   |         |         | Deprec-<br>iation,<br>inter-<br>est,<br>etc. | Total<br>all<br>costs |
|---|--------|---------|-------------------------------------|---------|----------------|---------|---------|---------|--|-----------------------|
|   |        | Feed    | shoeing,<br>barn<br>equip.,<br>etc. | etc.    |                |         |         |         |  |                       |
|   | Number | Dollars | Dollars                             | Dollars | Dollars        | Dollars | Dollars | Dollars | Dollars                                      | Dollars               |
| Mixed cash-crop-livestock farms             |        |         |                                     |         |                |         |         |         |  |                       |
| Under 50 acres                              | 8      | 55      | 6                                   | 9       | 6              | 76      |         |         |  |                       |
| 50-74 acres                                 | 29     | 72      | 11                                  | 18      | 12             | 113     |         |         |  |                       |
| 75-99 acres                                 | 16     | 120     | 18                                  | 34      | 21             | 193     |         |         |  |                       |
| 100-124 acres                               | 9      | 148     | 29                                  | 27      | 17             | 221     |         |         |  |                       |
| 125-149 acres                               | 21     | 157     | 26                                  | 30      | 46             | 259     |         |         |  |                       |
| 150-199 acres                               | 12     | 242     | 48                                  | 63      | 48             | 401     |         |         |  |                       |
| 200 acres and over                          | 9      | 299     | 55                                  | 61      | 81             | 496     |         |         |  |                       |
| Total or average                            | 104    | 141     | 25                                  | 32      | 30             | 228     |         |         |  |                       |
| Percentage of total                         |        | 61.8    | 11.0                                | 14.0    | 13.2           | 100.0   |         |         |  |                       |
| Total all farms                             |        |         |                                     |         |                |         |         |         |  |                       |
| Under 50 acres                              | 31     | 50      | 12                                  | 10      | 6              | 78      |         |         |  |                       |
| 50-74 acres                                 | 83     | 86      | 17                                  | 21      | 19             | 143     |         |         |  |                       |
| 75-99 acres                                 | 50     | 110     | 21                                  | 28      | 22             | 181     |         |         |  |                       |
| 100-124 acres                               | 29     | 143     | 26                                  | 34      | 13             | 216     |         |         |  |                       |
| 125-149 acres                               | 44     | 157     | 27                                  | 31      | 36             | 251     |         |         |  |                       |
| 150-199 acres                               | 27     | 201     | 37                                  | 50      | 31             | 319     |         |         |  |                       |
| 200 acres and over                          | 13     | 292     | 49                                  | 51      | 71             | 463     |         |         |  |                       |
| Total or average                            | 277    | 124     | 23                                  | 28      | 24             | 199     |         |         |  |                       |
| Percentage of total                         |        | 62.3    | 11.5                                | 14.1    | 12.1           | 100.0   |         |         |  |                       |

Table 24.- Average annual costs of operating power per hour of use and per horsepower hour, by type and size of farm, three major irrigated areas, southern Idaho, 1940

| Type and size of farm<br>(cultivated acres) | No. | Farms: | Total power on farms | Hours  | Tractors                |                                  |                 | Total power           |                   |                   |
|---|-----|--------|----------------------|--------|-------------------------|----------------------------------|-----------------|-----------------------|-------------------|-------------------|
|   |     |        |                      |        | Total use (inc. custom) | energy consumption (inc. custom) | operating costs | Costs per hour of use | Costs per HP hour | Costs per HP hour |
|   |     |        |                      |        | Dollars                 | HP hr.                           | Dollars         | Dollars               | Dollars           | Dollars           |
| <b>Livestock farms</b>                      |     |        |                      |        |                         |                                  |                 |                       |                   |                   |
| Under 50 acres                              | 8   | 18.29  | 338                  | 3,303  | 234                     | 0.69                             | 0.071           | 315                   | 0.076             |                   |
| 50-74 acres                                 | 12  | 20.18  | 350                  | 3,276  | 249                     | 0.71                             | 0.076           | 391                   | 0.086             |                   |
| 75-99 acres                                 | 8   | 22.37  | 266                  | 2,732  | 252                     | 0.95                             | 0.092           | 395                   | 0.072             |                   |
| 100-124 acres                               | 2   | 29.59  | 606                  | 4,737  | 630                     | 1.04                             | 0.133           | 720                   | 0.122             |                   |
| 125-149 acres                               | 3   | 25.11  | 557                  | 6,393  | 304                     | 0.55                             | 0.048           | 597                   | 0.055             |                   |
| 150-199 acres                               | 2   | 23.94  | 630                  | 6,030  | 381                     | 0.60                             | 0.063           | 561                   | 0.046             |                   |
| 200 acres and over                          | 1   | 46.65  | 412                  | 8,164  | 571                     | 1.39                             | 0.070           | 851                   | 0.045             |                   |
| Total or average                            | 36  | 22.18  | 378                  | 3,790  | 288                     | 0.76                             | 0.076           | 432                   | 0.071             |                   |
| <b>Cash-crop farms</b>                      |     |        |                      |        |                         |                                  |                 |                       |                   |                   |
| Under 50 acres                              | 15  | 15.28  | 355                  | 3,507  | 251                     | 0.71                             | 0.072           | 330                   | 0.070             |                   |
| 50-74 acres                                 | 42  | 19.69  | 408                  | 4,390  | 285                     | 0.70                             | 0.065           | 447                   | 0.064             |                   |
| 75-99 acres                                 | 26  | 21.48  | 520                  | 4,556  | 319                     | 0.61                             | 0.070           | 504                   | 0.069             |                   |
| 100-124 acres                               | 18  | 23.51  | 445                  | 4,465  | 374                     | 0.84                             | 0.084           | 601                   | 0.073             |                   |
| 125-149 acres                               | 20  | 22.98  | 623                  | 6,139  | 428                     | 0.69                             | 0.070           | 665                   | 0.062             |                   |
| 150-199 acres                               | 13  | 26.31  | 731                  | 7,909  | 462                     | 0.63                             | 0.058           | 727                   | 0.058             |                   |
| 200 acres and over                          | 3   | 45.38  | 648                  | 10,436 | 657                     | 1.01                             | 0.063           | 1,082                 | 0.058             |                   |
| Total or average                            | 137 | 21.73  | 495                  | 5,056  | 345                     | 0.70                             | 0.068           | 537                   | 0.065             |                   |

(Continued)



Table 24.- Average annual costs of operating power per hour of use and per horsepower hour, by type and size of farm, three major irrigated areas, southern Idaho, 1940 (Continued)

| Type and size of farm<br>(cultivated acres) | No. | Farms | Total power on farms | Total use | H. hr. | HP hr. | Horses        |              |                       |                          | Total power          |                          |                      |                          |
|---|-----|-------|----------------------|-----------|--------|--------|---------------|--------------|-----------------------|--------------------------|----------------------|--------------------------|----------------------|--------------------------|
|   |     |       |                      |           |        |        | Equiv. energy | Total opera- | Costs per hour of use | Costs per equiv. HP hour | Total costs per farm | Costs per equiv. HP hour | Total costs per farm | Costs per equiv. HP hour |
|   |     |       |                      |           |        |        | consump- tion | ting costs   |                       |                          |                      |                          |                      |                          |
| Livestock farms                             |     |       |                      |           |        |        |               |              |                       |                          |                      |                          |                      |                          |
| Under 50 acres                              | 8   |       | 18.29                | 428       | 862    | 81     | 0.19          | 0.094        | 0.19                  | 0.094                    | 315                  | 0.076                    | 315                  | 0.076                    |
| 50-74 acres                                 | 12  |       | 20.18                | 621       | 1,272  | 142    | 0.23          | 0.112        | 0.23                  | 0.112                    | 391                  | 0.086                    | 391                  | 0.086                    |
| 75-99 acres                                 | 8   |       | 22.37                | 1,306     | 2,744  | 143    | 0.11          | 0.052        | 0.11                  | 0.052                    | 395                  | 0.072                    | 395                  | 0.072                    |
| 100-124 acres                               | 2   |       | 29.59                | 586       | 1,151  | 90     | 0.15          | 0.078        | 0.15                  | 0.078                    | 720                  | 0.122                    | 720                  | 0.122                    |
| 125-149 acres                               | 3   |       | 25.11                | 2,113     | 4,483  | 293    | 0.14          | 0.065        | 0.14                  | 0.065                    | 597                  | 0.055                    | 597                  | 0.055                    |
| 150-199 acres                               | 2   |       | 23.94                | 2,990     | 6,062  | 180    | 0.06          | 0.030        | 0.06                  | 0.030                    | 561                  | 0.046                    | 561                  | 0.046                    |
| 200 acres and over                          | 1   |       | 46.65                | 4,665     | 10,598 | 280    | 0.06          | 0.026        | 0.06                  | 0.026                    | 851                  | 0.045                    | 851                  | 0.045                    |
| Total or average                            | 36  |       | 22.18                | 1,094     | 2,295  | 174    | 0.13          | 0.063        | 0.13                  | 0.063                    | 1,432                | 0.071                    | 1,432                | 0.071                    |
| Cash-crop farms                             |     |       |                      |           |        |        |               |              |                       |                          |                      |                          |                      |                          |
| Under 50 acres                              | 15  |       | 15.28                | 579       | 1,196  | 79     | 0.14          | 0.066        | 0.14                  | 0.066                    | 330                  | 0.070                    | 330                  | 0.070                    |
| 50-74 acres                                 | 42  |       | 19.69                | 1,234     | 2,560  | 162    | 0.13          | 0.063        | 0.13                  | 0.063                    | 447                  | 0.064                    | 447                  | 0.064                    |
| 75-99 acres                                 | 26  |       | 21.48                | 1,384     | 2,759  | 185    | 0.13          | 0.067        | 0.13                  | 0.067                    | 504                  | 0.069                    | 504                  | 0.069                    |
| 100-124 acres                               | 18  |       | 23.51                | 1,968     | 3,792  | 227    | 0.12          | 0.060        | 0.12                  | 0.060                    | 601                  | 0.073                    | 601                  | 0.073                    |
| 125-149 acres                               | 20  |       | 22.98                | 2,400     | 4,650  | 237    | 0.10          | 0.051        | 0.10                  | 0.051                    | 665                  | 0.062                    | 665                  | 0.062                    |
| 150-199 acres                               | 13  |       | 26.31                | 2,462     | 4,675  | 265    | 0.11          | 0.057        | 0.11                  | 0.057                    | 727                  | 0.058                    | 727                  | 0.058                    |
| 200 acres and over                          | 3   |       | 45.38                | 3,738     | 8,181  | 425    | 0.11          | 0.052        | 0.11                  | 0.052                    | 1,082                | 0.058                    | 1,082                | 0.058                    |
| Total or average                            | 137 |       | 21.73                | 1,628     | 3,240  | 192    | 0.12          | 0.059        | 0.12                  | 0.059                    | 537                  | 0.065                    | 537                  | 0.065                    |

(Continued)

Table 24.- Average annual costs of operating power per hour of use and per horsepower hour, by type and size of farm, three major irrigated areas, southern Idaho, 1940 (Continued)

| Type and size<br>of farm<br>(cultivated acres) | Farms |                               |                                  | Tractors  |                                  |                                   | Total power                |                               |                                      |
|--|-------|-------------------------------|----------------------------------|---|----------------------------------|-----------------------------------|----------------------------|-------------------------------|--------------------------------------|
|  | No.   | Total<br>power<br>on<br>farms | Total<br>use<br>(inc.<br>custom) | Total<br>energy<br>consump-<br>tion<br>(inc.<br>custom) | Total<br>opera-<br>ting<br>costs | Costs<br>per<br>hour<br>of<br>use | Costs<br>per<br>HP<br>hour | Total<br>costs<br>per<br>farm | Costs<br>per<br>equiv.<br>HP<br>hour |
|  | No.   | EHP                           | Hours                            | HP hr.  | Dollars                          | Dollars                           | Dollars                    | Dollars                       | Dollars                              |
| Mixed cash-crop-livestock farms                |       |                               |                                  |   |                                  |                                   |                            |                               |                                      |
| Under 50 acres                                 | 8     | 13.93                         | 334                              | 2,596   | 176                              | 0.53                              | 0.068                      | 252                           | 0.077                                |
| 50-74 acres                                    | 29    | 16.21                         | 393                              | 3,271   | 230                              | 0.59                              | 0.070                      | 343                           | 0.063                                |
| 75-99 acres                                    | 16    | 20.88                         | 443                              | 4,169   | 325                              | 0.73                              | 0.078                      | 518                           | 0.071                                |
| 100-124 acres                                  | 9     | 21.14                         | 661                              | 5,851   | 325                              | 0.49                              | 0.056                      | 546                           | 0.052                                |
| 125-149 acres                                  | 21    | 24.88                         | 617                              | 6,542   | 373                              | 0.60                              | 0.057                      | 632                           | 0.059                                |
| 150-199 acres                                  | 12    | 31.76                         | 476                              | 5,886   | 509                              | 1.07                              | 0.086                      | 910                           | 0.067                                |
| 200 acres and over                             | 9     | 30.89                         | 894                              | 10,342  | 575                              | 0.64                              | 0.056                      | 1,071                         | 0.059                                |
| Total or average                               | 104   | 22.09                         | 518                              | 5,155   | 340                              | 0.66                              | 0.066                      | 568                           | 0.062                                |
| Total all farms                                |       |                               |                                  |   |                                  |                                   |                            |                               |                                      |
| Under 50 acres                                 | 31    | 15.75                         | 345                              | 3,218   | 227                              | 0.66                              | 0.071                      | 305                           | 0.073                                |
| 50-74 acres                                    | 83    | 18.61                         | 395                              | 3,838   | 261                              | 0.66                              | 0.068                      | 404                           | 0.066                                |
| 75-99 acres                                    | 50    | 21.47                         | 455                              | 4,141   | 310                              | 0.68                              | 0.075                      | 491                           | 0.070                                |
| 100-124 acres                                  | 29    | 23.20                         | 524                              | 4,914   | 376                              | 0.72                              | 0.077                      | 592                           | 0.067                                |
| 125-149 acres                                  | 44    | 24.02                         | 616                              | 6,349   | 393                              | 0.64                              | 0.062                      | 644                           | 0.060                                |
| 150-199 acres                                  | 27    | 28.61                         | 610                              | 6,870   | 477                              | 0.78                              | 0.069                      | 796                           | 0.061                                |
| 200 acres and over                             | 13    | 35.50                         | 800                              | 10,196  | 593                              | 0.74                              | 0.058                      | 1,056                         | 0.058                                |
| Total or average                               | 277   | 21.93                         | 489                              | 4,929   | 336                              | 0.69                              | 0.068                      | 535                           | 0.064                                |

(Continued)

Table 24.- Average annual costs of operating power per hour of use and per horsepower hour, by type and size of farm, three major irrigated areas, southern Idaho, 1940 (Continued)

| Type and size of farm (cultivated acres) | Farms | No.   | Total power on farms | Total use | H. hr. | HP hr. | Horses                    |                       |                       | Costs               |                |                   | Total power |                      |                   |
|--|-------|-------|----------------------|-----------|--------|--------|---------------------------|-----------------------|-----------------------|---------------------|----------------|-------------------|-------------|----------------------|-------------------|
|  |       |       |                      |           |        |        | Equiv. energy consumption | Total operating costs | Costs per hour of use | Costs per equiv. HP | Costs per farm | Costs per HP hour | Total costs | Total costs per farm | Costs per HP hour |
| Mixed cash-crop-livestock farms          |       |       |                      |           |        |        |                           |                       |                       |                     |                |                   |             |                      |                   |
| Under 50 acres                           | 8     | 13.93 | 279                  | 627       | 76     | 0.27   | 0.121                     | 0.052                 | 0.061                 | 0.047               | 0.062          | 0.052             | 252         | 0.077                | 0.063             |
| 50-74 acres                              | 29    | 16.21 | 1,065                | 2,194     | 113    | 0.11   | 0.052                     | 0.061                 | 0.047                 | 0.062               | 0.059          | 0.067             | 343         | 0.071                | 0.052             |
| 75-99 acres                              | 16    | 20.88 | 1,540                | 3,165     | 193    | 0.13   | 0.061                     | 0.047                 | 0.062                 | 0.059               | 0.067          | 0.052             | 518         | 0.059                | 0.067             |
| 100-124 acres                            | 9     | 21.14 | 2,281                | 4,733     | 221    | 0.10   | 0.062                     | 0.059                 | 0.067                 | 0.052               | 0.067          | 0.052             | 546         | 0.059                | 0.067             |
| 125-149 acres                            | 21    | 24.88 | 2,093                | 4,211     | 259    | 0.11   | 0.065                     | 0.057                 | 0.059                 | 0.067               | 0.052          | 0.067             | 632         | 0.059                | 0.067             |
| 150-199 acres                            | 12    | 31.76 | 3,844                | 7,772     | 401    | 0.12   | 0.065                     | 0.057                 | 0.059                 | 0.067               | 0.052          | 0.067             | 910         | 0.059                | 0.067             |
| 200 acres and over                       | 9     | 30.89 | 3,980                | 7,679     | 496    | 0.12   | 0.065                     | 0.057                 | 0.059                 | 0.067               | 0.052          | 0.067             | 1,071       | 0.059                | 0.067             |
| Total or average                         | 104   | 22.09 | 1,963                | 3,968     | 228    | 0.12   | 0.057                     | 0.059                 | 0.059                 | 0.059               | 0.059          | 0.059             | 568         | 0.062                | 0.062             |
| Total all farms                          |       |       |                      |           |        |        |                           |                       |                       |                     |                |                   |             |                      |                   |
| Under 50 acres                           | 31    | 15.75 | 463                  | 964       | 78     | 0.17   | 0.081                     | 0.064                 | 0.063                 | 0.055               | 0.057          | 0.061             | 305         | 0.073                | 0.066             |
| 50-74 acres                              | 83    | 18.61 | 1,087                | 2,246     | 143    | 0.13   | 0.064                     | 0.063                 | 0.055                 | 0.057               | 0.052          | 0.061             | 404         | 0.066                | 0.070             |
| 75-99 acres                              | 50    | 21.47 | 1,421                | 2,886     | 181    | 0.11   | 0.055                     | 0.057                 | 0.052                 | 0.058               | 0.056          | 0.058             | 491         | 0.067                | 0.060             |
| 100-124 acres                            | 29    | 23.20 | 1,970                | 3,902     | 216    | 0.11   | 0.057                     | 0.052                 | 0.058                 | 0.056               | 0.058          | 0.058             | 592         | 0.061                | 0.058             |
| 125-149 acres                            | 44    | 24.02 | 2,234                | 4,428     | 251    | 0.10   | 0.052                     | 0.058                 | 0.056                 | 0.058               | 0.056          | 0.058             | 644         | 0.061                | 0.058             |
| 150-199 acres                            | 27    | 28.61 | 3,115                | 6,155     | 319    | 0.12   | 0.058                     | 0.056                 | 0.058                 | 0.056               | 0.058          | 0.058             | 796         | 0.058                | 0.058             |
| 200 acres and over                       | 13    | 35.50 | 3,977                | 8,020     | 463    | 0.12   | 0.058                     | 0.056                 | 0.058                 | 0.056               | 0.058          | 0.058             | 1,056       | 0.058                | 0.058             |
| Total or average                         | 277   | 21.93 | 1,685                | 3,390     | 199    | 0.12   | 0.059                     | 0.059                 | 0.059                 | 0.059               | 0.059          | 0.059             | 535         | 0.064                | 0.064             |



shown are that when costs are calculated on the basis of energy consumption of work accomplished, as reflected in energy consumption, use of horses on an average of all field work was only slightly lower in costs than was use of tractors. Operating costs for animal power were 6 cents per equivalent horsepower hour, as compared with 7 cents per horsepower hour of tractors. Furthermore, operating costs for mechanical power increased with the size of the power unit but decreased slightly per horsepower hour as the size of power unit increased. Operating costs for horses increased and decreased with extent of use, as total annual costs are relatively fixed. From the standpoint of costs per unit of work accomplished, horses were little lower in operating costs than tractors. Furthermore, on farms spending more for purchased feeds than these irrigated farms, operating costs for horses may well equal or exceed those of mechanical power as calculated on this basis. If operating costs of tractors and horses as well as labor costs are considered, the use of tractors becomes considerably more economical than that of horses.

In preceding discussions of tractor-operating costs, total costs and costs per hour of use and per horsepower hour were given by type and size of farm. Size of power and extent of annual use entered the results only insofar as they were reflected by type and size of farm. The size of the available power unit and the extent to which this unit is used, however, greatly influence operating costs. The main reason is the fact that fixed costs represent a relatively large proportion of total costs for all sizes of power units. Their significance decreases as annual use increases. For the following analysis of operating costs by size of tractor and extent of annual use, only farms on which one tractor was in use were employed. The number of farms by size groups of tractors and extent of use are given in table 35, page 119. More than 90 percent of all farms had tractors of less than 20 HP; almost 70 percent were between 10 and 20 HP. Almost 90 percent of all farms used their tractors less than 600 hours annually, 60 percent were in groups that showed 200 to 600 hours of use, and 14 percent of the tractors were used less than 200 hours.

In table 25, operating costs for tractors are given by size of tractor and extent of annual use, together with data as to size of farm, total consumption of energy, and extent of work done by mechanical power. The extent of use of a tractor depends not only upon the size of farm and its organization, including the types of crops grown, but also upon the amount of animal power available. The proportion of work done by the tractor increased with size of farm.

Costs per hour of use of tractors increased from 56 cents for tractors under 10 horsepower to more than \$1.00 for tractors from 20 to 25 horsepower. On the other hand, operating costs per horsepower hour declined slightly as the size of the power unit increased.

Tractor operating costs, both per hour of use and per horsepower hour, declined rapidly as extent of annual use increased. Operating costs on farms on which tractors were used from 800 to 1,000 hours were only about 37 percent of costs on farms on which the tractor was used under 200 hours.

### USE OF LABOR ON TRACTOR FARMS

In a study of the use of power on farms, attention must necessarily be given to the use of labor. It is a displacement of manual labor, a shortening of working hours, or in general, an easing of the labor load, frequently accompanied by a reduction in operation costs, which is achieved or at least attempted by the use of mechanical power and its supplementary equipment.

On the average of all types and sizes of farms in the three irrigated areas of southern Idaho, farm operators spent slightly less than one year's work in operating their farms (table 26). No consistent variation was found in the amount of operator's labor on various sizes and types of farms except that the number of man-days spent by the operator was slightly higher on farms specializing in livestock production than the average of all farms. The labor of the operator and other family members per farm was highest in the Upper Snake River Area, where on the average farms were larger than in the other areas, and lowest in the Twin Falls-Minidoka Area, where the number of farms that specialized in livestock production was smallest. The amount of family labor generally increased with the size of farm. There were exceptions in which additional labor needs were met chiefly by employment of regularly hired or seasonal workers.

The total labor used on farms increased less than in proportion to the size of farm, resulting in a decline in the number of man-days per cultivated acre as the size of farm increased. Farms with less than 50 crop acres used almost twice the labor per acre compared with farms of more than 200 crop acres.

Table 25.- Average operating costs of tractor, and annual use of tractor,<sup>1/</sup>  
by type of farm and by size, three major irrigated areas,  
southern Idaho, 1940

| Size of tractor<br>and<br>extent of use | : Av. size: Average: Total : Percent: Tractor oper-       |       |       |          |         |         |         |
|---|---|-------|-------|----------|---------|---------|---------|
|   | : Farms: of farm : rating : energy : of work: ating costs |       |       |          |         |         |         |
|   | : (cultiv.: of : consumption: done by: Per hour: Per HP   |       |       |          |         |         |         |
|   | : acres) : tractor: of tractor : tractor: of use : hour   |       |       |          |         |         |         |
|   | No.   | Acres | DBHP  | HP hours | Percent | Dollars | Dollars |
| Livestock farms                         |   |       |       |          |         |         |         |
| Size of tractor                         |   |       |       |          |         |         |         |
| Under 10 HP .                           | 5   | 70    | 9.40  | 4,908    | 59      | 0.59    | 0.08    |
| 10-14.99 HP .                           | 12  | 71    | 11.91 | 4,357    | 52      | 0.64    | 0.09    |
| 15-19.99 HP .                           | 12  | 92    | 17.10 | 6,688    | 57      | 0.86    | 0.07    |
| 20-24.99 HP .                           | 4   | 49    | 21.10 | 6,338    | 58      | 1.10    | 0.07    |
| 25 HP and over                          | --  | --    | --    | --       | --      | --      | --      |
| Annual use                              |   |       |       |          |         |         |         |
| Under 200 hours:                        | 8   | 57    | 14.56 | 3,161    | 44      | 1.08    | 0.11    |
| 200- 399 hours :                        | 12  | 78    | 15.54 | 4,675    | 52      | 1.06    | 0.10    |
| 400- 599 hours :                        | 9   | 82    | 14.10 | 6,836    | 58      | 0.74    | 0.07    |
| 600- 799 hours :                        | 3   | 77    | 11.26 | 7,377    | 64      | 0.41    | 0.05    |
| 800- 999 hours :                        | --  | --    | --    | --       | --      | --      | --      |
| 1000-1199 hours :                       | 1   | 148   | 15.98 | 17,381   | 72      | 0.34    | 0.03    |
| 1200 hours and                          | :   | :     | :     | :        | :       | :       | :       |
| over . . . . .                          | --  | --    | --    | --       | --      | --      | --      |
| Average . .                             | 33  | 76    | 14.53 | 5,528    | 56      | 0.76    | 0.08    |
| Cash-crop farms                         |   |       |       |          |         |         |         |
| Size of tractor                         |   |       |       |          |         |         |         |
| Under 10 HP .                           | 26  | 90    | 9.61  | 6,315    | 59      | 0.60    | 0.08    |
| 10-14.99 HP .                           | 56  | 80    | 12.33 | 6,748    | 54      | 0.62    | 0.07    |
| 15-19.99 HP .                           | 34  | 101   | 17.52 | 8,714    | 52      | 0.85    | 0.07    |
| 20-24.99 HP .                           | 10  | 151   | 22.16 | 12,419   | 56      | 0.98    | 0.06    |
| 25 HP and over                          | 1   | 58    | 25.11 | 3,693    | 58      | 1.40    | 0.08    |
| Annual use                              |   |       |       |          |         |         |         |
| Under 200 hours:                        | 18  | 68    | 14.69 | 4,797    | 34      | 1.54    | 0.16    |
| 200- 399 hours :                        | 53  | 89    | 14.62 | 6,600    | 46      | 0.92    | 0.10    |
| 400- 599 hours :                        | 25  | 93    | 12.83 | 7,595    | 58      | 0.67    | 0.07    |
| 600- 799 hours :                        | 19  | 117   | 13.13 | 9,836    | 64      | 0.56    | 0.06    |
| 800- 999 hours :                        | 8   | 126   | 15.43 | 11,336   | 78      | 0.50    | 0.05    |
| 1000-1199 hours :                       | 3   | 68    | 10.42 | 11,974   | 72      | 0.32    | 0.03    |
| 1200 hours and                          | :   | :     | :     | :        | :       | :       | :       |
| over . . . . .                          | 1   | 142   | 19.13 | 26,740   | 85      | 0.37    | 0.03    |
| Average . .                             | 127   | 93    | 14.04 | 7,608    | 55      | 0.71    | 0.07    |

<sup>1/</sup> Includes only farms having one tractor each.

(Continued)



Table 25.- Average operating costs of tractor, and annual use of tractor,<sup>1/</sup>  
by type of farm and by size, three major irrigated areas,  
southern Idaho, 1940 (Continued)

| Size of tractor<br>and<br>extent of use | : Av. size: Average: Total : Percent: Tractor oper-<br>: of farm : rating : energy : of work: ating costs<br>: Farms : (cultiv.: of : consumption: done by: Per hour: Per HP<br>: : acres) : tractor: of tractor : tractor: of use : hour<br>: No. : Acres : DBHP : HP hours : Percent: Dollars : Dollars |     |       |        |    |      |      |
|---|---|-----|-------|--------|----|------|------|
|   |   |     |       |        |    |      |      |
|   |   |     |       |        |    |      |      |
| Mixed cash-crop-                        | :   | :   | :     | :      | :  | :    | :    |
| livestock farms                         | :   | :   | :     | :      | :  | :    | :    |
| Size of tractor                         | :   | :   | :     | :      | :  | :    | :    |
| Under 10 HP . .                         | : 28 :  | 84  | 9.42  | 6,045  | 59 | 0.51 | 0.07 |
| 10-14.99 HP . .                         | : 30 :  | 100 | 12.42 | 7,436  | 50 | 0.66 | 0.08 |
| 15-19.99 HP . .                         | : 36 :  | 129 | 17.36 | 11,234 | 61 | 0.69 | 0.06 |
| 20-24.99 HP . .                         | : 4 :   | 139 | 21.57 | 18,217 | 26 | 1.03 | 0.07 |
| 25 HP and over                          | : 1 :   | 209 | 28.97 | 18,226 | 50 | 0.78 | 0.05 |
| Annual use                              | :   | :   | :     | :      | :  | :    | :    |
| Under 200 hours                         | : 9 :   | 82  | 14.60 | 5,437  | 34 | 1.25 | 0.12 |
| 200- 399 hours                          | : 31 :  | 89  | 12.77 | 7,173  | 41 | 0.78 | 0.08 |
| 400- 599 hours                          | : 28 :  | 100 | 13.59 | 7,939  | 56 | 0.64 | 0.07 |
| 600- 799 hours                          | : 15 :  | 138 | 16.43 | 12,013 | 61 | 0.71 | 0.06 |
| 800- 999 hours                          | : 10 :  | 131 | 13.80 | 11,519 | 72 | 0.52 | 0.05 |
| 1000-1199 hours                         | : 5 :   | 153 | 14.13 | 15,363 | 65 | 0.35 | 0.04 |
| 1200 hours and                          | :   | :   | :     | :      | :  | :    | :    |
| over . . . . .                          | : 1 :   | 297 | 13.56 | 22,021 | 61 | 0.64 | 0.06 |
| Average . . .                           | : 99 :  | 108 | 13.90 | 8,968  | 54 | 0.64 | 0.06 |
| Total all farms                         | :   | :   | :     | :      | :  | :    | :    |
| Size of tractor                         | :   | :   | :     | :      | :  | :    | :    |
| Under 10 HP . .                         | : 59 :  | 86  | 9.50  | 6,067  | 59 | 0.56 | 0.08 |
| 10-14.99 HP . .                         | : 98 :  | 85  | 12.31 | 6,666  | 52 | 0.64 | 0.08 |
| 15-19.99 HP . .                         | : 82 :  | 112 | 17.39 | 9,524  | 57 | 0.76 | 0.06 |
| 20-24.99 HP . .                         | : 18 :  | 126 | 21.80 | 12,356 | 46 | 1.01 | 0.06 |
| 25 HP and over                          | : 2 :   | 134 | 27.04 | 10,960 | 51 | 0.92 | 0.06 |
| Annual use                              | :   | :   | :     | :      | :  | :    | :    |
| Under 200 hours                         | : 35 :  | 69  | 14.63 | 4,588  | 36 | 1.37 | 0.14 |
| 200- 399 hours                          | : 96 :  | 87  | 14.14 | 6,544  | 45 | 0.89 | 0.10 |
| 400- 599 hours                          | : 62 :  | 94  | 13.36 | 7,640  | 57 | 0.64 | 0.07 |
| 600- 799 hours                          | : 37 :  | 122 | 14.31 | 10,519 | 63 | 0.61 | 0.06 |
| 800- 999 hours                          | : 18 :  | 128 | 14.52 | 11,438 | 75 | 0.51 | 0.05 |
| 1000-1199 hours                         | : 9 :   | 124 | 11.32 | 14,457 | 68 | 0.34 | 0.03 |
| 1200 hours and                          | :   | :   | :     | :      | :  | :    | :    |
| over . . . . .                          | : 2 :   | 220 | 16.35 | 24,381 | 74 | 0.44 | 0.04 |
| Average . . .                           | : 259 :   | 97  | 14.05 | 7,863  | 55 | 0.68 | 0.07 |

<sup>1/</sup> Includes only farms having one tractor each.

Table 26.- Kind and amount of labor used on farms, by size of farm and area, southern Idaho, 1940

| Item                                 | : Farms :  | : Cultivated : |      | : Other : |       | : Regular : |       | : Seasonal : |       | : Total : |            |
|--------------------------------------|------------|----------------|------|-----------|-------|-------------|-------|--------------|-------|-----------|------------|
|                                      |            | acres          | per  | family    | labor | hired       | labor | hired        | labor | labor     | per        |
|                                      | : Number : | Acres          | farm | labor     | labor | labor       | labor | labor        | used  | Man-days  | culti-     |
| Size of farm                         |            |                |      |           |       |             |       |              |       |           | vated acre |
| Under 50 acres . . . . .             | 31 :       | 36.8           | 279  | 11        | 20    | 41          | 381   | 10.4         |       |           |            |
| 50-74 acres . . . . .                | 83 :       | 64.0           | 283  | 84        | 72    | 85          | 524   | 8.2          |       |           |            |
| 75-99 acres . . . . .                | 50 :       | 85.8           | 272  | 92        | 109   | 133         | 606   | 7.1          |       |           |            |
| 100-124 acres . . . . .              | 29 :       | 112.6          | 273  | 164       | 154   | 154         | 745   | 6.6          |       |           |            |
| 125-149 acres . . . . .              | 144 :      | 135.1          | 291  | 126       | 185   | 166         | 768   | 5.7          |       |           |            |
| 150-199 acres . . . . .              | 27 :       | 170.3          | 296  | 278       | 207   | 104         | 885   | 5.2          |       |           |            |
| 200 acres and over . . . . .         | 13 :       | 238.8          | 262  | 174       | 569   | 324         | 1,329 | 5.6          |       |           |            |
| Area                                 |            |                |      |           |       |             |       |              |       |           |            |
| Upper Snake River Area . . . . .     | 89 :       | 120.0          | 286  | 162       | 175   | 91          | 714   | 6.0          |       |           |            |
| Percent of total labor . . . . .     | -- :       | --             | 40   | 23        | 24    | 13          | 100   | --           |       |           |            |
| Twin Falls-Minidoka Area . . . . .   | 98 :       | 96.3           | 277  | 80        | 121   | 151         | 629   | 6.5          |       |           |            |
| Percent of total labor . . . . .     | -- :       | --             | 44   | 13        | 19    | 24          | 100   | --           |       |           |            |
| Boise-Caldwell Area . . . . .        | 90 :       | 83.8           | 280  | 118       | 114   | 120         | 632   | 7.5          |       |           |            |
| Percent of total labor . . . . .     | -- :       | --             | 44   | 19        | 18    | 19          | 100   | --           |       |           |            |
| Total all sizes, all areas . . . . . | 277 :      | 99.8           | 281  | 119       | 136   | 122         | 658   | 6.6          |       |           |            |
| Percent of total labor . . . . .     | -- :       | --             | 43   | 18        | 21    | 18          | 100   | --           |       |           |            |

This difference in the amount of labor per acre was surprisingly large considering that the study included only farms on which tractors were in use. In the Upper Snake River Area, where the average size of farm was largest, the total labor used per acre was smaller than in the other areas. The highest average labor use per acre was found in the Boise-Caldwell Area, where a comparatively large number of dairy farms and some double-cropping tended to increase the use of labor per acre.

Specialized livestock farms used the most labor in relation to size, particularly in the Boise-Caldwell Area, where dairy-ing predominated. In the Upper Snake River Area, where livestock enterprises consisted chiefly of range livestock, the use of labor per cultivated acre on specialized livestock farms was lower than on farms of other types which were comparable in size expressed in cultivated acres.

On cash-crop farms, areas varied considerably in use of labor per cultivated acre. This was because of the predominant types of cash crops grown, intensity of production, and length of season, which may permit one or more crops to be grown on the same field. Thus, the average labor used on cash-crop farms was lowest in the Upper Snake River Area and highest in the Boise-Caldwell Area. For all areas, the amount of labor per cultivated acre on this type of farm was below that for other types with more or less important livestock enterprises.

On the average of all farms, the labor used in the operation of power and equipment was about equally divided between field work and other work on the farm, such as belt work and hauling. Approximately 6 percent of the total labor used per farm in operating power and equipment was for hired operations and almost 7 percent of the total farm labor was used for custom work. Therefore, work hired was more than offset by custom work done. At an average rate of 8 hours per day, the amount of labor spent in the operation of power and equipment was 194 man-days per farm, or approximately 2 man-days per acre.

Labor used in the operation of power and equipment per acre was largest on small farms and decreased as size of farm increased (table 27). The decrease is particularly marked when farms with less than 100 acres of cropland are compared with those having more than 100 acres.





Of the total labor used in the operation of power and equipment, a larger portion is employed to operate animal power than mechanical power (table 28). On farms with less than 50 acres of cultivated land, nearly half of the total labor for operation of power was used to operate mechanical power, while on farms with more than 150 acres less than a third of the labor operated this type of power. A greater proportion of horses on the larger farms and a greater need for man-labor per unit of animal power were the main reasons for this relationship. Another reason is shown by relating man-hours to horsepower hours used. Horsepower hours per man-hour increased with the size of farm. In other words, as the size of farm increased, an increase in the size of the tractor reduced labor needs. On the other hand, the number of horse-hours per man-hour showed no consistent change as the size of farm increased. On irrigated farms the most common size of animal power unit was a two-horse team. The size of team used did not increase with size of farm but additional work was done by additional teams which required additional man-labor.

In tables 32 and 33, the work accomplished per 10-hour day and the average number of man-hours per acre are given for all individual field operations reported by types of power and sizes of implements, regardless of the adequacy of the sample. Although smaller implements were generally used with teams, the amount of labor using horses for many field operations averaged more than twice the labor used per acre using tractors. Even for comparable sizes of implements and a sufficiently large number of cases, man-labor using horses was twice the amount of that using tractors in operations in which the tractor was unable to overcome an unfavorable relationship between power and implement by greater speed.

This may be illustrated by comparing labor use for harrowing with that for drilling grain. In harrowing, a tractor pulling a two-, three-, or four-section spiketooth harrow could generally overcome the disadvantage of an insufficient load by greater speed. Labor used was half that when horses were employed to pull an implement of the same size. In drilling grain, the tractor, by greater speed, could not fully overcome the disadvantage of an insufficient load. Labor used was more than half that using horses to pull the same size of drill. Labor use in production of crops, as discussed here, includes labor employed in operation of power for field work only. Therefore, labor use for such work as irrigating crops or other necessary hand labor, including hauling jobs, must be added to obtain total labor use for various crops.



Table 28.- Total labor used per farm in the operation of major types of power and equipment<sup>1/</sup> and energy consumption per man-hour, by size of farm, three major irrigated areas, southern Idaho, 1940

| Size grouping of farms<br>and<br>major irrigated areas | : | : Labor used for: |                         |              |              | : Labor for: |        |              |              | : Horse |                    | : Percentage of<br>total labor<br>used for oper-<br>ating tractor<br>and equipment |                 |
|--|---|-------------------|-------------------------|--------------|--------------|--------------|--------|--------------|--------------|---------|--------------------|--|-----------------|
|  |   | : operating       |                         | : operating: |              | : operating: |        | : operating: |              | : hours | : per man-<br>hour |  |                 |
|  |   | : power and       | : equipment,            | : tractor    | : and        | : tractor    | : and  | : tractor    | : and        |         |                    |  |                 |
|  |   |                   | : on farm <sup>1/</sup> |              | : equipment: |              | : hour |              | : hour       |         | : hour             |  | : and equipment |
|  |   | : Number:         | : Man-hours             |              | : Man-hours: | : HP         | : hour | : Man-hours: | : Horse hr.: |         | : Percent          |  | : Percent       |
| Size of farm   | : | :                 | :                       | :            | :            | :            | :      | :            | :            | :       | :                  | :  | :               |
| Under 50 acres   | : | :                 | 556                     | :            | 258          | 7.16         | :      | 298          | 1.55         | :       | 46.4               | :  | :               |
| 50-74 acres  | : | 31 :              | 990                     | :            | 333          | 7.36         | :      | 657          | 1.65         | :       | 33.6               | :  | :               |
| 75-99 acres  | : | 83 :              | 1,323                   | :            | 447          | 7.76         | :      | 876          | 1.62         | :       | 33.8               | :  | :               |
| 100-124 acres  | : | 50 :              | 1,671                   | :            | 545          | 8.08         | :      | 1,126        | 1.75         | :       | 32.6               | :  | :               |
| 125-149 acres  | : | 29 :              | 1,951                   | :            | 646          | 9.05         | :      | 1,305        | 1.71         | :       | 33.1               | :  | :               |
| 150-199 acres  | : | 44 :              | 2,384                   | :            | 671          | 9.27         | :      | 1,713        | 1.82         | :       | 28.1               | :  | :               |
| 200 acres and over                                     | : | 27 :              | 3,276                   | :            | 924          | 10.40        | :      | 2,352        | 1.69         | :       | 28.2               | :  | :               |
|  | : | 13 :              | :                       | :            | :            | :            | :      | :            | :            | :       | :                  | :  | :               |
| Area   | : | :                 | :                       | :            | :            | :            | :      | :            | :            | :       | :                  | :  | :               |
| Upper Snake River Area                                 | : | 89 :              | 1,864                   | :            | 501          | 9.55         | :      | 1,363        | 1.70         | :       | 26.9               | :  | :               |
| Twin Falls-Minidoka Area                               | : | 98 :              | 1,485                   | :            | 445          | 8.04         | :      | 1,040        | 1.79         | :       | 30.0               | :  | :               |
| Boise-Caldwell Area                                    | : | 90 :              | 1,061                   | :            | 491          | 7.59         | :      | 570          | 1.52         | :       | 46.3               | :  | :               |
| Total or average, all sizes,<br>all areas              | : | 277 :             | 1,469                   | :            | 478          | 8.40         | :      | 991          | 1.70         | :       | 32.5               | :  | :               |

<sup>1/</sup> Total man-labor on farm used in the operation of power and equipment, excluding labor for hired and custom work.



Similar to the classification of power used in production of major crops, labor use has been shown in table 29 by major groups of field operations, that is, land preparation, planting, crop cultivation, and harvesting. For grain crops, about 40 percent of the total labor used in operation of power was used in land preparation. These operations required a somewhat higher proportion of the total horsepower hours used. In all other groups of field operations, horsepower hours used constituted a smaller proportion as compared with the proportion of labor used for various groups of field operations. A somewhat higher labor use per acre of barley than of wheat was due chiefly to the crop rotation and the need for plowing on a larger proportion of farms. Planting and cultivation of grain crops required relatively small amounts of labor, while harvesting constituted a major load for available labor. Total labor use for operating power in production of grain crops averaged about 6.5 man-hours.

Greater amounts of power and labor were used in production of row crops. In this respect, potatoes and sugar beets were quite similar. Preparation of land, because of the particular place these crops occupied in the rotation, showed approximately equal amounts of labor used. The planting of potatoes required more time per acre and consequently showed a higher use of labor than the planting of sugar beets. Slightly more labor was used in cultivating potatoes than sugar beets, while the harvesting of beets required more labor than that of potatoes. In total, potatoes used about one hour more labor per acre than sugar beets. Use of labor in operation of power per acre of potatoes was about 14.5 man-hours; that for sugar beets, between 13 and 13.5 hours. For dry beans, which were important in the Twin Falls-Minidoka Area only, the use of labor for operating power was lower than for the other major row crops. However, a proportionately larger amount of the total was devoted to preparation of land. Planting and cultivating operations for beans required relatively small amounts of labor. Harvesting beans consisted of a series of field operations, each using small amounts of labor which in total equalled or exceeded those for other row crops. Total labor use for machine operation in field work per acre of beans was slightly over 12 man-hours.

On irrigated farms alfalfa is an important crop in the rotation. Therefore, the amount of labor used per acre, as well as the total for this crop, is significant. Labor use for this crop applies to established stands only; thus, in addition to the other limitation mentioned above, no allowance is made for planting operations.

Table 29.- Average amount of labor used for operating power and equipment per acre of specified crops by major groups of operation, three major irrigated areas, southern Idaho, 1940

| Item                               | Land preparation:   |                 |         | Planting       |                 |         | Crop cultivation: |                 |         | Harvesting     |                 |         | Total all operations |                 |         |
|------------------------------------|---------------------|-----------------|---------|----------------|-----------------|---------|-------------------|-----------------|---------|----------------|-----------------|---------|----------------------|-----------------|---------|
|                                    | Employ-<br>ing      | tractors:horses | Man-hr. | Employ-<br>ing | tractors:horses | Man-hr. | Employ-<br>ing    | tractors:horses | Man-hr. | Employ-<br>ing | tractors:horses | Man-hr. | Employ-<br>ing       | tractors:horses | Man-hr. |
| Wheat . . . . .                    | 2.1                 | 1.4             | 1.0     | 0.6            | 1.0             | 0.5     | 1.0               | 1.0             | 2.1     | 1.9            | 1.9             | 4.5     | 2.4                  | 6.4             |         |
| Barley . . . . .                   | 2.3                 | 1.4             | 1.0     | 0.6            | 1.0             | 0.5     | 1.0               | 1.0             | 1.9     | 1.2            | 1.2             | 4.7     | 2.6                  | 6.8             |         |
| Potatoes . . . . .                 | 3.2                 | 1.9             | 2.3     | 1.6            | 2.3             | 2.9     | 5.3               | 5.3             | 2.7     | 2.8            | 2.8             | 8.3     | 7.5                  | 14.4            |         |
| Sugar beets . . . . .              | 2.8                 | 2.3             | 1.0     | 0.8            | 1.0             | 3.5     | 5.2               | 5.2             | 1.9     | 3.6            | 3.6             | 5.3     | 9.3                  | 13.3            |         |
| Beans . . . . .                    | 3.3                 | 2.1             | 0.8     | 0.8            | 0.9             | 1.3     | 3.3               | 3.3             | 1.7     | 1.6            | 1.6             | 5.8     | 6.8                  | 12.1            |         |
| Alfalfa (two cuttings) . . . . .   | (Established stand) |                 |         |                |                 |         |                   |                 |         |                |                 |         |                      |                 |         |
| Alfalfa (three cuttings) . . . . . | (Established stand) |                 |         |                |                 |         |                   |                 |         |                |                 |         |                      |                 |         |

In almost all cases, alfalfa was seeded with wheat or barley as a nurse crop and both power and labor use attributable to seeding alfalfa could not be segregated from that for the nurse crop. In the Upper Snake River Area, two cuttings of alfalfa were the general rule, while in the major areas to the west, which have longer growing seasons, three cuttings were made. Cultivation of alfalfa fields was a more common practice where three cuttings were made, and this increased the total labor use per acre for field operations on these fields. Harvesting on fields with three cuttings required generally a third more labor. Thus, per cutting, there was no significant difference between the amount of labor used on fields of two or three cuttings. Total labor use amounted to almost 4 hours on fields with two cuttings, and 6 man-hours on fields with three cuttings.

The preceding discussions have included the increase in the use of labor as well as that of power accompanying an increase in the size of farm. The significant points were that labor increased by about 36 man-days of work for each 10 acres of cultivated land on cash-crop farms and by almost 50 man-days for each 10 acres on mixed cash-crop-livestock farms, a considerably greater proportionate increase on the latter than on the former. Use of power, on the other hand, did not show a proportionately greater increase on mixed cash-crop-livestock farms. On these farms, with each increase of 10 acres in size of farm, as measured by number of cultivated acres, consumption of energy increased by 865 horsepower hours, while on specialized cash-crop farms an increase of 775 horsepower hours accompanied a 10-acre increase in size of farm (figure 6).



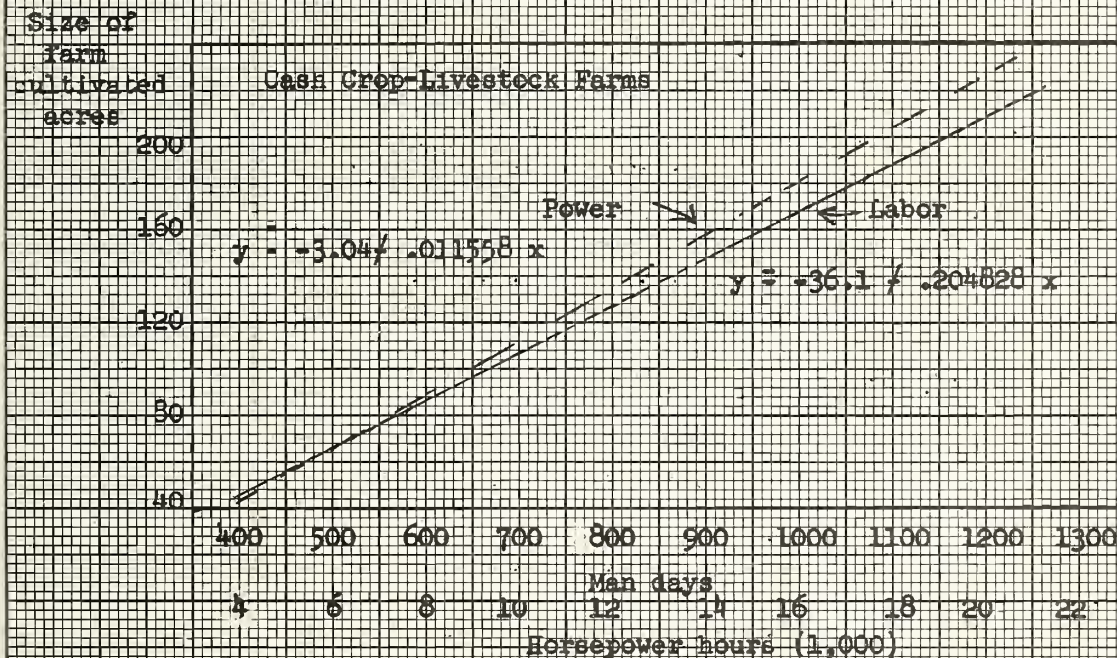
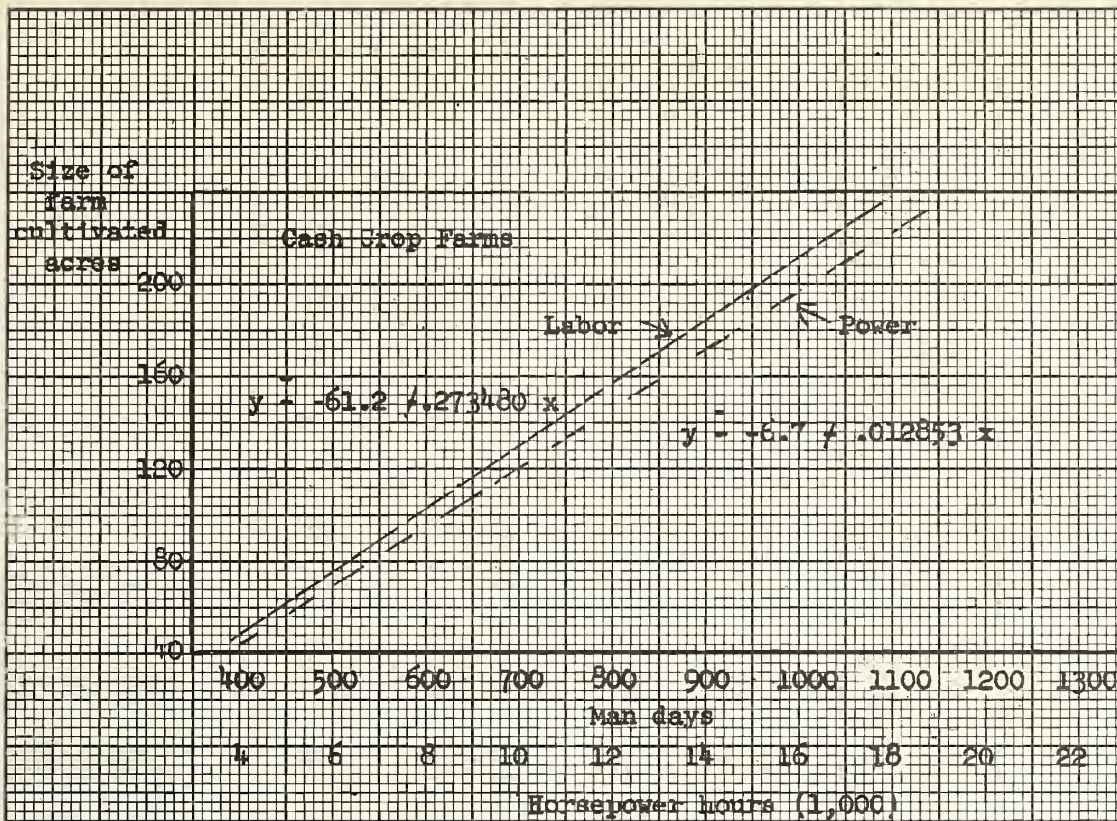


Figure 6.- Size of farm as related to labor and power consumption, three irrigated areas, southern Idaho, 1940



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| Size grouping<br>of tractors | Tires |   |            | Spade |   |            | Cleats |   |            |
|------------------------------|-------|---|------------|-------|---|------------|--------|---|------------|
|                              | No.   | Average: hours :<br>rating : per :<br>: gallon: | HP<br>hr.: | No.   | Average: hours :<br>rating : per :<br>: gallon: | HP<br>hr.: | No.    | Average: hours :<br>rating : per :<br>: gallon: | HP<br>hr.: |
| Tractors using gasoline      |       |   |            |       |   |            |        |   |            |
| Under 10.00 HP               | --    | --  | --         | 1     | 9.74  | 6.27       | 1.608  | --  | --         |
| 10.00-14.99 HP               | 4     | 13.18   | 9.20       | 1     | 11.27   | 6.27       | 1.728  | --  | --         |
| 15.00-19.99 HP               | 3     | 16.57   | 8.96       | 4     | 17.18   | 6.99       | 2.510  | 5   | 18.04      |
| 20.00-24.99 HP               | 3     | 22.11   | 9.21       | --    | --  | --         | --     | 1   | 21.81      |
| 25.00-29.99 HP               | 1     | 28.97   | 9.37       | --    | --  | --         | --     | --  | --         |
| Total or average             | 11    | 17.98   | 9.15       | 6     | 14.96   | 6.82       | 2.230  | 6   | 18.66      |
| Tractors using distillate    |       |   |            |       |   |            |        |   |            |
| Under 10.00 HP               | 1     | 9.68  | 10.16      | 2     | 9.16  | 6.78       | 1.410  | --  | --         |
| 10.00-14.99 HP               | 5     | 11.47   | 9.26       | 6     | 12.31   | 6.35       | 1.826  | --  | --         |
| 15.00-19.99 HP               | 2     | 18.06   | 9.11       | 8     | 17.27   | 6.92       | 2.432  | 1   | 18.86      |
| 20.00-24.99 HP               | 1     | 20.12   | 9.57       | 6     | 21.98   | 6.57       | 3.331  | 1   | 22.79      |
| 25.00-29.99 HP               | --    | --  | --         | --    | --  | --         | --     | --  | --         |
| 30.00-34.99 HP               | 1     | 30.46   | 8.78       | 1     | 32.04   | 10.05      | 3.198  | --  | --         |
| Total or average             | 10    | 15.37   | 9.30       | 23    | 17.14   | 5.93       | 2.453  | 2   | 20.82      |

Table 31.- Calculation of horsepower hours used by Tractor X on Farm Y, three major irrigated areas, southern Idaho, 1940<sup>1</sup>

| Survey data                       |                   |           |             |         |         |         |                      |         |         |         |                   |         | Computations |         |        |               |
|-----------------------------------|-------------------|-----------|-------------|---------|---------|---------|----------------------|---------|---------|---------|-------------------|---------|--------------|---------|--------|---------------|
| Field operation                   | Size of implement | Gear used | Total hours |         |         |         | Hours of actual work |         |         |         | Fuel used per day | Acreage |              | Total   |        | Adjusted DBHP |
|                                   |                   |           | of          | work    | per day | per day | field                | work    | per day | covered |                   | actual  | consumption  | season  | HP hr. |               |
|                                   |                   |           | hours       | per day | per day | per day | hours                | per day | per day | hours   | gallons           | gallons | hours        | gallons | HP hr. | HP hr.        |
| Plowing sod . . . .               | 1 - 14-inch       | I         | 10.5        | 10.0    | 10.0    | 4.0     | 16.0                 | 13.0    | 33      | 52.0    | 280.3             | 21.6    |              |         |        |               |
| Plowing stubble . .               | 1 - 14-inch       | II        | 10.5        | 10.0    | 10.0    | 5.0     | 15.0                 | 7.5     | 15      | 22.5    | 121.3             | 16.2    |              |         |        |               |
| Plowing row-crop land . . . . .   | 1 - 14-inch       | III       | 10.5        | 10.0    | 10.0    | 6.0     | 16.0                 | 5.0     | 9       | 13.5    | 72.8              | 14.6    |              |         |        |               |
| Leveling . . . . .                | 9-foot            | I         | 10.5        | 10.0    | 10.0    | 15.0    | 16.0                 | 31.5    | 21      | 33.6    | 181.1             | 5.7     |              |         |        |               |
| Leveling . . . . .                | 9-foot            | II        | 10.5        | 10.0    | 10.0    | 22.0    | 15.0                 | 87.0    | 40      | 59.4    | 320.2             | 3.7     |              |         |        |               |
| Disking plowed land               | 6-foot tandem     | II        | 10.5        | 10.0    | 10.0    | 18.0    | 14.0                 | 63.0    | 35      | 49.0    | 264.1             | 4.2     |              |         |        |               |
| Harrowing, spring-tooth . . . . . | 2-section         | I         | 9.0         | 8.0     | 8.0     | 16.0    | 13.0                 | 14.0    | 7       | 11.5    | 62.0              | 4.4     |              |         |        |               |
| Harrowing, spike-tooth . . . . .  | 2-section         | III       | 10.5        | 10.0    | 10.0    | 40.0    | 13.0                 | 16.0    | 4       | 5.2     | 28.0              | 1.8     |              |         |        |               |
| Planting beets . . .              | 4-row             | I         | 6.0         | 5.0     | 5.0     | 10.0    | 7.0                  | 10.0    | 5       | 7.0     | 37.7              | 3.8     |              |         |        |               |
| Planting potatoes . .             | 2-row             | I         | 8.0         | 6.0     | 6.0     | 6.0     | 9.0                  | 6.0     | 6       | 9.0     | 48.5              | 8.1     |              |         |        |               |
| Seeding grain . . . .             | 6-foot drill      | III       | 4.0         | 3.0     | 3.0     | 7.0     | 4.0                  | 7.0     | 3       | 4.0     | 21.6              | 3.1     |              |         |        |               |
| Cultivating beets . .             | 4-row             | I         | 8.0         | 7.5     | 7.5     | 10.0    | 10.0                 | 7.0     | 5       | 7.0     | 37.7              | 5.4     |              |         |        |               |
| Cultivating potatoes              | 2-row             | II        | 8.0         | 7.5     | 7.5     | 12.0    | 10.0                 | 24.0    | 15      | 20.0    | 107.8             | 4.5     |              |         |        |               |
| Binding grain . . . .             | 5-foot            | II        | 6.0         | 5.0     | 5.0     | 8.0     | 7.5                  | 7.0     | 5       | 6.6     | 35.6              | 5.1     |              |         |        |               |
|                                   |                   |           |             |         |         |         |                      | Total   | 203     | 300.3   | 1618.7            |         |              |         |        |               |

1/ Make and rating of tractor; type of traction: spade; type of fuel: distillate; Nebr. test No. X; adjusted drawbar HP hours per gallon: 5.39; gallons per hour: 1.258-1.589<sup>2</sup>; speed of gears (mph): I-2.52; II-3.34; III-4.33.

2/ For "varying" and rated load at the drawbar; data used for checking purposes only.



Table 32.- Summary of tractor field operations, three major irrigated areas, southern Idaho, 1940. (1)

| Field operation                  | Cases  | Width of implement | Average tractor rating | Speed of operation | Fuel per acre | Work per 10-hr. day | Hours used per acre | Man-hours per acre |
|----------------------------------|--------|--------------------|------------------------|--------------------|---------------|---------------------|---------------------|--------------------|
|                                  | Number |                    | DBHP                   | MPH                | Gal.          | Acres               | HF hr.              | Hours              |
| Land preparation                 |        |                    |                        |                    |               |                     |                     |                    |
| Plowing sod or alfalfa           | 20     | 1 bottom-14-inch   | 12.03                  | 3.26               | 3.2           | 4.5                 | 20.9                | 2.4                |
|                                  | 105    | 1 bottom-16-inch   | 11.92                  | 3.22               | 3.4           | 4.5                 | 22.4                | 2.4                |
|                                  | 40     | 1 bottom-16-inch   | 16.16                  | 3.57               | 3.4           | 5.6                 | 23.4                | 1.9                |
|                                  | 2      | 1 bottom-20-inch   | 15.25                  | 3.18               | 3.7           | 5.8                 | 23.1                | 1.8                |
|                                  | 3      | 2 bottom-12-inch   | 13.78                  | 3.01               | 3.0           | 5.6                 | 20.1                | 1.9                |
|                                  | 48     | 2 bottom-14-inch   | 16.48                  | 2.90               | 3.2           | 6.9                 | 19.3                | 1.6                |
|                                  | 9      | 2 bottom-16-inch   | 19.15                  | 3.12               | 3.3           | 8.2                 | 20.7                | 1.3                |
|                                  | 1      | 3 bottom-12-inch   | 19.34                  | 2.55               | 3.5           | 7.8                 | 17.7                | 1.4                |
|                                  | 3      | 3 bottom-14-inch   | 24.75                  | 2.57               | 3.4           | 9.1                 | 24.6                | 1.3                |
|                                  | 1      | 5 bottom-10-inch   | 25.11                  | 3.83               | 1.9           | 5.8                 | 13.1                | 0.7                |
| Average                          | 232    | 20-inch            | 14.19                  | 3.20               | 3.3           | 5.5                 | 21.7                | 2.0                |
| Plowing row-crop land or stubble |        |                    |                        |                    |               |                     |                     |                    |
|                                  | 19     | 1 bottom-14-inch   | 11.53                  | 3.70               | 2.6           | 5.2                 | 16.5                | 2.0                |
|                                  | 114    | 1 bottom-16-inch   | 12.09                  | 3.61               | 2.7           | 5.5                 | 17.5                | 2.0                |
|                                  | 39     | 1 bottom-18-inch   | 16.15                  | 4.06               | 2.7           | 6.9                 | 18.1                | 1.6                |
|                                  | 2      | 1 bottom-20-inch   | 15.25                  | 4.26               | 2.4           | 8.2                 | 15.0                | 1.3                |
|                                  | 5      | 2 bottom-12-inch   | 15.56                  | 3.45               | 2.4           | 7.3                 | 16.8                | 1.5                |
|                                  | 52     | 2 bottom-14-inch   | 16.38                  | 3.51               | 2.4           | 8.7                 | 14.7                | 1.3                |
|                                  | 16     | 2 bottom-16-inch   | 18.99                  | 3.55               | 2.5           | 10.3                | 13.8                | 1.1                |
|                                  | 1      | 3 bottom-12-inch   | 19.34                  | 3.55               | 2.3           | 11.1                | 11.7                | 1.0                |
|                                  | 3      | 3 bottom-14-inch   | 24.75                  | 3.80               | 2.3           | 12.6                | 16.7                | 0.9                |
|                                  | 1      | 5 bottom-10-inch   | 25.11                  | 3.83               | 1.5           | 18.2                | 10.1                | 0.6                |
| Average                          | 252    | 20.4-inch          | 14.33                  | 3.67               | 2.6           | 6.8                 | 16.6                | 1.6                |

1/ Includes servicing of equipment and two-man crews where used in operation of machines. (Continued)

Table 32.- Summary of tractor field operations, three major irrigated areas, southern Idaho, 1940 (Continued) (2)

| Field operation  | Cases  | Width of implement | Average tractor rating | Speed of operation | Fuel per acre | Work           |          | Man-hours |
|--|--------|--------------------|------------------------|--------------------|---------------|----------------|----------|-----------|
|  |        |                    |                        |                    |               | per 10-hr. day | per acre |           |
|  | Number |                    | DBHP                   | MPH                | Gal.          | Acres          | HP hr.   | Hours     |
| Land preparation   |        |                    |                        |                    |               |                |          |           |
| Crowning alfalfa   | 1      | 1. bottom-14-inch  | 9.68                   | 3.39               | 2.3           | 3.6            | 17.7     | 3.0       |
|  | 5      | 1. bottom-16-inch  | 10.61                  | 4.12               | 2.0           | 6.3            | 12.2     | 1.7       |
|  | 5      | 1. bottom-18-inch  | 15.60                  | 4.51               | 2.2           | 8.0            | 15.8     | 1.4       |
|  | 1      | 2. bottom-14-inch  | 17.69                  | 4.49               | 1.5           | 10.6           | 12.0     | 1.0       |
|  | 1      | 2. bottom-16-inch  | 19.70                  | 3.72               | 3.0           | 8.3            | 18.7     | 1.3       |
| Average  | 13     | 18.8-inch          | 13.70                  | 4.21               | 2.2           | 7.1            | 14.5     | 1.5       |
| Deep tilling   |        |                    |                        |                    |               |                |          |           |
|  | 5      | 5-foot             | 14.51                  | 3.20               | 1.0           | 16.0           | 7.0      | 0.7       |
|  | 3      | 6-foot             | 12.68                  | 3.25               | .8            | 19.7           | 5.2      | 0.6       |
|  | 6      | 7-foot             | 14.99                  | 3.28               | .9            | 21.0           | 6.2      | 0.6       |
|  | 4      | 8-foot             | 17.93                  | 3.42               | 1.0           | 20.3           | 7.2      | 0.6       |
|  | 2      | 10-foot            | 18.10                  | 3.60               | 1.6           | 16.3           | 9.6      | 0.7       |
| Average  | 20     | 6.8-foot           | 15.42                  | 3.32               | 1.0           | 18.9           | 6.8      | 0.6       |
| Disking and harrowing--tandem disk   |        |                    |                        |                    |               |                |          |           |
|  | 3      | 6-foot             | 15.12                  | 3.03               | .9            | 19.6           | 5.9      | 0.5       |
|  | 16     | 7-foot             | 14.99                  | 3.27               | 1.0           | 21.6           | 5.5      | 0.5       |
|  | 14     | 8-foot             | 16.94                  | 3.38               | .8            | 25.7           | 4.8      | 0.4       |
|  | 1      | 9-foot             | 20.27                  | 4.02               | 1.0           | 27.8           | 6.8      | 0.4       |
|  | 1      | 10-foot            | 20.52                  | 3.25               | .9            | 30.0           | 4.6      | 0.3       |
| Average  | 35     | 7.5-foot           | 16.09                  | 3.31               | .9            | 23.5           | 5.3      | 0.5       |
| 1/ Includes servicing of equipment and two-man crews where used in operation of machines (Continued) |        |                    |                        |                    |               |                |          |           |

Table 32.- Summary of tractor field operations, three major irrigated areas, southern Idaho, 1940 (Continued) (3)

| Field operation                             | Cases  | Width of implement | Average tractor rating | Speed of operation | Fuel per acre | Work per 10-hr. day | HP used per acre | Man-hours per acre |
|---|--------|--------------------|------------------------|--------------------|---------------|---------------------|------------------|--------------------|
| and preparation                             | Number |                    | DBHP                   | MPH                | Gal.          | Acres               | HP hr.           | Hours              |
| Disking and harrowing--single disk          | 2      | 6-foot             | 13.36                  | 3.20               | 1.0           | 19.0                | 6.4              | 0.6                |
|   | 4      | 7-foot             | 13.77                  | 3.49               | .8            | 20.8                | 5.7              | 0.5                |
|   | 5      | 8-foot             | 13.35                  | 3.21               | .7            | 24.2                | 5.4              | 0.5                |
|   | 2      | 10-foot            | 15.50                  | 3.78               | .4            | 33.2                | 3.1              | 0.3                |
| Average                                     | 13     | 7.7-foot           | 13.81                  | 3.38               | .8            | 23.8                | 5.3              | 0.5                |
| Disking--tandem                             | 1      | 4-foot             | 8.80                   | 2.68               | 2.3           | 6.0                 | 14.5             | 2.0                |
|   | 5      | 5-foot             | 12.14                  | 3.21               | 1.0           | 17.0                | 6.8              | 0.6                |
|   | 49     | 6-foot             | 11.79                  | 3.44               | .8            | 20.3                | 5.0              | 0.5                |
|   | 65     | 7-foot             | 13.71                  | 3.36               | .8            | 22.7                | 5.0              | 0.5                |
|   | 33     | 8-foot             | 16.05                  | 3.38               | 1.0           | 25.3                | 5.0              | 0.4                |
|   | 8      | 10-foot            | 14.82                  | 3.43               | .8            | 30.7                | 3.6              | 0.5                |
| Average                                     | 161    | 7-foot             | 13.58                  | 3.38               | .8            | 22.6                | 5.1              | 0.5                |
| Disking--single                             | 4      | 6-foot             | 11.22                  | 3.35               | .6            | 21.7                | 4.3              | 0.5                |
|   | 5      | 7-foot             | 13.76                  | 3.57               | .6            | 28.8                | 4.1              | 0.4                |
|   | 6      | 8-foot             | 15.13                  | 3.21               | .7            | 25.2                | 4.9              | 0.4                |
|   | 3      | 10-foot            | 13.61                  | 2.87               | .8            | 21.4                | 5.6              | 0.5                |
|   | 2      | 12-foot            | 16.58                  | 3.40               | .4            | 46.0                | 2.8              | 0.2                |
| Average                                     | 20     | 8-foot             | 13.93                  | 3.30               | .7            | 26.9                | 4.5              | 0.4                |
| Cultivating and harrowing--field cultivator | 3      | 6-foot             | 12.29                  | 3.14               | .8            | 20.8                | 5.2              | 0.6                |
|   | 1      | 7-foot             | 14.80                  | 3.40               | 1.0           | 15.8                | 7.8              | 0.7                |
|   | 2      | 8-foot             | 13.79                  | 2.73               | .8            | 20.6                | 5.2              | 0.5                |
|   | 1      | 9.5-foot           | 17.85                  | 3.05               | .7            | 30.6                | 3.8              | 0.3                |
| Average                                     | 7      | 7.2-foot           | 13.87                  | 3.05               | .8            | 21.5                | 5.4              | 0.5                |

Includes servicing of equipment and two-man crews where used in operation of machines. (Continued)













Table 32.- Summary of tractor field operations, three major irrigated areas, southern Idaho, 1940 (Continued) (8)

| Field operation        | Cases   | Width of implement | Average tractor rating |      | Speed of operation |     | Fuel per acre |         | Work per 10-hr. |        | Man-hours used per acre |       |
|------------------------|---------|--------------------|------------------------|------|--------------------|-----|---------------|---------|-----------------|--------|-------------------------|-------|
|                        |         |                    | DBHP                   | MPH  | Gal.               | MPH | per acre      | per day | Acres           | HP hr. | per acre                | Hours |
| Planting               | Number: |                    |                        |      |                    |     |               |         |                 |        |                         |       |
| Planting peas--drill   | 2       | 7-foot             | 16.35                  | 4.01 | .6                 |     |               | 26.2    |                 | 5.0    | 0.5                     |       |
| Average                | 2       | 8-foot             | 16.19                  | 3.50 | .8                 |     |               | 25.6    |                 | 5.2    | 0.7                     |       |
|                        | 7       | 7.5-foot           | 16.27                  | 3.76 | .7                 |     |               | 26.0    |                 | 5.1    | 0.6                     |       |
| Planting peas--planter | 10      | 4-row              | 11.17                  | 3.58 | .6                 |     |               | 23.6    |                 | 3.7    | 0.8                     |       |
| Planting corn          | 1       | 1-row              | 16.22                  | 4.83 | 1.2                |     |               | 14.3    |                 | 8.7    | 0.8                     |       |
| Average                | 10      | 2-row              | 11.60                  | 3.46 | .8                 |     |               | 18.8    |                 | 4.9    | 0.7                     |       |
|                        | 11      | 1.9-row            | 12.02                  | 3.58 | .8                 |     |               | 18.3    |                 | 5.2    | 0.7                     |       |
| Crop cultivation       |         |                    |                        |      |                    |     |               |         |                 |        |                         |       |
| Listing row crops      | 5       | 2-row              | 14.87                  | 3.63 | 0.7                |     |               | 23.1    |                 | 4.6    | 0.5                     |       |
| Average                | 2       | 3-row              | 13.19                  | 3.80 | .6                 |     |               | 22.4    |                 | 4.3    | 0.5                     |       |
|                        | 3       | 4-row              | 10.83                  | 3.02 | .9                 |     |               | 13.0    |                 | 6.0    | 0.9                     |       |
|                        | 1       | 5-row              | 9.74                   | 3.66 | .5                 |     |               | 26.7    |                 | 2.9    | 0.4                     |       |
|                        | 11      | 3-row              | 12.99                  | 3.50 | .7                 |     |               | 20.8    |                 | 4.8    | 0.5                     |       |
| Fertilizing            | 1       | 10-foot            | 12.68                  | 2.84 | .4                 |     |               | 33.3    |                 | 2.6    | 0.3                     |       |
| Average                | 3       | 2-row              | 10.84                  | 2.71 | 1.0                |     |               | 11.5    |                 | 7.0    | 1.0                     |       |
|                        | 2       | 4-row              | 9.31                   | 4.28 | .4                 |     |               | 30.5    |                 | 2.5    | 0.4                     |       |
|                        | 6       |                    | 10.63                  | 3.26 | .7                 |     |               | 20.2    |                 | 4.7    | 0.6                     |       |
| Weeding                | 3       | 8-foot             | 14.74                  | 3.80 | .6                 |     |               | 27.2    |                 | 3.7    | 0.4                     |       |
| Average                | 6       | 10-foot            | 14.03                  | 3.41 | .5                 |     |               | 31.7    |                 | 3.3    | 0.3                     |       |
|                        | 1       | 12-foot            | 9.74                   | 2.73 | .4                 |     |               | 33.3    |                 | 2.5    | 0.3                     |       |
|                        | 10      | 9.6-foot           | 13.81                  | 3.46 | .5                 |     |               | 30.5    |                 | 3.4    | 0.4                     |       |

1/ Includes servicing of equipment and two-man crews where used in operation of machines.

(Continued)

Table 32.- Summary of tractor field operations, three major irrigated areas, southern Idaho, 1940 (Continued) (9)

| Field operation                 | Cases  | Width of implement | Average tractor rating | Speed of operation | Fuel per acre | Work per 10-hr. day | Man-hours used per acre |
|---------------------------------|--------|--------------------|------------------------|--------------------|---------------|---------------------|-------------------------|
|                                 | Number |                    | DBHP                   | MPH                | Gal.          | Acre                | HP hr.                  |
| Crop cultivation                |        |                    |                        |                    |               |                     |                         |
| Cultivating potatoes            | 19     | 1-row              | 12.13                  | 3.68               | 1.0           | 11.9                | 7.3                     |
|                                 | 86     | 2-row              | 13.66                  | 3.41               | .8            | 19.9                | 5.3                     |
|                                 | 2      | 3-row              | 15.71                  | 3.61               | .5            | 38.3                | 3.1                     |
|                                 | 1      | 4-row              | 19.13                  | 3.88               | .5            | 41.2                | 3.6                     |
| Average                         | 108    | 1.9-row            | 13.48                  | 3.47               | .8            | 19.2                | 5.6                     |
| Cultivating beets               | 61     | 4-row              | 11.85                  | 3.19               | .7            | 20.8                | 4.7                     |
|                                 | 3      | 6-row              | 16.22                  | 3.31               | .9            | 22.9                | 6.1                     |
| Average                         | 64     | 4-row              | 12.06                  | 3.20               | .7            | 20.9                | 4.8                     |
| Cultivating beans               | 28     | 4-row              | 11.84                  | 3.30               | .6            | 23.4                | 4.1                     |
| Cultivating corn                | 5      | 1-row              | 12.01                  | 3.37               | 1.2           | 10.7                | 9.0                     |
|                                 | 29     | 2-row              | 13.73                  | 3.33               | .9            | 18.6                | 5.7                     |
| Average                         | 34     | 1.9-row            | 13.48                  | 3.34               | .9            | 17.8                | 6.2                     |
| Cultivating vegetable row crops | 1      | 2-row              | 10.76                  | 3.04               | .9            | 14.7                | 6.6                     |
|                                 | 61     | 4-row              | 10.99                  | 2.91               | .9            | 16.2                | 6.1                     |
|                                 | 2      | 6-row              | 13.01                  | 2.68               | .4            | 24.6                | 3.2                     |
| Average                         | 64     | 4-row              | 11.05                  | 2.90               | .9            | 16.5                | 6.0                     |

/ Includes servicing of equipment and two-man crews where used in operation of machines. (Continued)



Table 32.- Summary of tractor field operations, three major irrigated areas, southern Idaho, 1940 (Continued) (10)

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| Field operation | Cases  | Width of implement | Average tractor rating | Speed of operation | Fuel per acre | Work per 10-hr. day | HP used per acre | Man-hours per acre |
|-----------------|--------|--------------------|------------------------|--------------------|---------------|---------------------|------------------|--------------------|
|                 | Number |                    | DBHP                   | MPH                | Gal.          | Acres               | HP hr.           | Hours              |
| Harvesting      |        |                    |                        |                    |               |                     |                  |                    |
| Mowing alfalfa  | 21     | 5-foot             | 11.43                  | 3.50               | .7            | 16.7                | 4.9              | 0.7                |
|                 | 23     | 6-foot             | 11.29                  | 3.92               | .6            | 21.0                | 4.3              | 0.5                |
|                 | 129    | 7-foot             | 14.40                  | 3.77               | .7            | 25.4                | 4.3              | 0.4                |
| Average         | 173    | 6.6-foot           | 13.63                  | 3.76               | .7            | 23.8                | 4.4              | 0.5                |
| Raking hay      | 2      | 7-foot             | 12.78                  | 3.34               | 0.6           | 22.1                | 3.9              | 0.5                |
|                 | 9      | 8-foot             | 12.88                  | 3.72               | .5            | 27.3                | 3.3              | 0.4                |
|                 | 13     | 9-foot             | 11.84                  | 3.58               | .4            | 30.7                | 2.8              | 0.4                |
|                 | 12     | 10-foot            | 11.08                  | 4.05               | .4            | 35.3                | 2.4              | 0.3                |
| Average         | 36     | 9-foot             | 11.90                  | 3.76               | .4            | 30.0                | 2.9              | 0.4                |
| Bunching hay    | 1      | 7-foot             | 12.68                  | 2.84               | .6            | 21.0                | 3.5              | 0.5                |
|                 | 1      | 9-foot             | 17.69                  | 4.49               | .4            | 45.7                | 3.1              | 0.5                |
|                 | 6      | 10-foot            | 9.78                   | 3.88               | .4            | 41.3                | 1.9              | 0.3                |
|                 | 1      | 12-foot            | 11.35                  | 3.38               | .5            | 17.6                | 4.0              | 0.6                |
| Average         | 9      | 9.8-foot           | 11.15                  | 3.77               | .4            | 35.2                | 2.5              | 0.5                |
| Binding grain   | 7      | 5-foot             | 12.88                  | 3.54               | 1.1           | 15.0                | 6.7              | 1.3                |
|                 | 38     | 6-foot             | 14.35                  | 3.27               | 1.0           | 16.3                | 6.9              | 1.3                |
|                 | 12     | 7-foot             | 13.31                  | 3.12               | .9            | 18.7                | 5.2              | 1.3                |
|                 | 6      | 8-foot             | 14.46                  | 3.26               | .8            | 23.0                | 4.6              | 0.9                |
|                 | 6      | 10-foot            | 15.19                  | 3.07               | .9            | 23.3                | 5.6              | 1.0                |
| Average         | 69     | 6.6-foot           | 14.10                  | 3.26               | 1.0           | 17.9                | 6.3              | 1.3                |
| Combining grain | 3      | 3-foot             | 11.57                  | 2.92               | 1.7           | 7.7                 | 12.1             | 3.0                |
|                 | 9      | 5-foot             | 13.67                  | 2.38               | 1.5           | 11.5                | 10.0             | 2.2                |
|                 | 5      | 6-foot             | 17.79                  | 2.31               | 1.6           | 12.4                | 12.0             | 1.8                |

Includes servicing of equipment and two-man crews where used in operation of machines.

(Continued)

Table 32.- Summary of tractor field operations, three major irrigated areas, southern Idaho, 1940 (Continued) (11)

| Harvesting<br>Field<br>operation | Cases   | Width<br>of<br>implement | Average:    |       |  | Fuel:      |       |          | Work:      |  |  | Man-      |  |  |
|----------------------------------|---------|--------------------------|-------------|-------|--|------------|-------|----------|------------|--|--|-----------|--|--|
|                                  |         |                          | : Speed :   |       |  | : of :     |       |          | : per :    |  |  | : hours : |  |  |
|                                  |         |                          | : tractor : |       |  | : opera- : |       |          | : 10-hr. : |  |  | : per :   |  |  |
|                                  |         |                          | : rating :  |       |  | : tion :   |       |          | : day :    |  |  | : acre :  |  |  |
|                                  | Number: |                          | DBHP :      | MPH : |  | Gal. :     | Acre: | HP hr. : | Hours      |  |  |           |  |  |
| Combining grain (Continued)      | 5       | 8-foot                   | 12.65       | 2.90  |  | 1.3        | 14.0  | 8.6      | 1.9        |  |  |           |  |  |
|                                  | 2       | 10-foot                  | 13.65       | 2.72  |  | 1.2        | 15.0  | 7.6      | 1.6        |  |  |           |  |  |
|                                  | 1       | 12-foot                  | 17.85       | 3.33  |  | .7         | 33.3  | 4.8      | 1.2        |  |  |           |  |  |
| Average                          | 25      | 6.2-foot                 | 14.20       | 2.60  |  | 1.5        | 12.8  | 10.0     | 2.1        |  |  |           |  |  |
| Digging potatoes                 | 123     | 1-row                    | 14.15       | 2.45  |  | 2.6        | 7.0   | 17.2     | 2.7        |  |  |           |  |  |
|                                  | 3       | 2-row                    | 18.89       | 2.27  |  | 2.0        | 11.4  | 15.6     | 1.4        |  |  |           |  |  |
| Average                          | 126     | 1-row                    | 14.26       | 2.45  |  | 2.6        | 7.1   | 17.1     | 2.6        |  |  |           |  |  |
| Lifting beats                    | 13      | 1-row                    | 12.22       | 3.10  |  | 2.6        | 5.5   | 17.8     | 2.2        |  |  |           |  |  |
|                                  | 10      | 2-row                    | 11.50       | 3.05  |  | 1.7        | 8.8   | 9.8      | 1.4        |  |  |           |  |  |
| Average                          | 23      | 1.4-row                  | 11.90       | 3.08  |  | 2.2        | 6.9   | 14.5     | 1.8        |  |  |           |  |  |
| Cutting beans                    | 3       | 2-row                    | 10.27       | 3.56  |  | .8         | 16.8  | 5.1      | 0.6        |  |  |           |  |  |
|                                  | 15      | 4-row                    | 11.42       | 3.74  |  | .6         | 22.6  | 3.7      | 0.5        |  |  |           |  |  |
| Average                          | 18      | 3.7-row                  | 11.25       | 3.71  |  | .6         | 21.6  | 3.9      | 0.5        |  |  |           |  |  |

1/ Includes servicing of equipment and two-man crews where used in operation of machines.

Table 33.- Summary of horse field operations, three major irrigated areas, southern Idaho, 1940

| Field operation                            | Cases  | Width of implement | Number of horses | Work per 10-hour day | Horse hours per acre | Equiv. HP per acre | Man-hours per acre <sup>1/</sup> |
|--|--------|--------------------|------------------|----------------------|----------------------|--------------------|----------------------------------|
|  | Number |                    | Number           | Acres                | Hours                | EHP hr.            | Hours                            |
| Land preparation                           |        |                    |                  |                      |                      |                    |                                  |
| Harrowing, spike-tooth . . . . .           | 37     | 2-section          | 2                | 17.3                 | 1.3                  | 1.9                | 0.6                              |
|  | 24     | 2-section          | 3                | 17.4                 | 1.9                  | 2.8                | 0.6                              |
|  | 21     | 2-section          | 4                | 20.0                 | 2.2                  | 3.2                | 0.6                              |
|  | 17     | 3-section          | 2                | 23.8                 | 0.9                  | 1.4                | 0.5                              |
|  | 7      | 3-section          | 3                | 21.2                 | 1.6                  | 2.3                | 0.5                              |
|  | 46     | 3-section          | 4                | 27.7                 | 1.6                  | 2.3                | 0.4                              |
|  | 9      | 4-section          | 4                | 26.4                 | 1.7                  | 2.6                | 0.4                              |
| Cultipacking or rolling . . . . .          | 28     | 8-foot             | 2                | 18.3                 | 1.2                  | 2.6                | 0.6                              |
|  | 10     | 10-foot            | 2                | 17.8                 | 1.4                  | 3.0                | 0.6                              |
|  | 2      | 12-foot            | 2                | 30.5                 | 0.9                  | 1.8                | 0.4                              |
| Marking out--vegetable row crops . . . . . | 4      | 4-row              | 2                | 14.3                 | 2.2                  | 4.3                | 1.2                              |
| Leveling . . . . .                         | 6      | 8-foot             | 2                | 13.8                 | 1.7                  | 3.2                | 0.8                              |
|  | 5      | 8-foot             | 3                | 10.6                 | 2.9                  | 5.2                | 1.0                              |
|  | 12     | 8-foot             | 4                | 17.8                 | 2.5                  | 4.6                | 0.6                              |
|  | 3      | 10-foot            | 2                | 15.3                 | 1.3                  | 2.5                | 0.7                              |
|  | 3      | 10-foot            | 3                | 16.5                 | 2.1                  | 4.0                | 0.7                              |
|  | 14     | 10-foot            | 4                | 17.3                 | 2.7                  | 4.9                | 0.6                              |
|  | 6      | 12-foot            | 4                | 24.7                 | 1.8                  | 3.4                | 0.4                              |
| Diking . . . . .                           | 25     | ---                | 2                | 29.8                 | 0.9                  | 2.1                | 0.4                              |
| Corrugating . . . . .                      | 30     | 2-row              | 2                | 10.6                 | 2.1                  | 4.2                | 1.0                              |
|  | 48     | 3-row              | 2                | 12.0                 | 1.8                  | 3.5                | 0.9                              |
|  | 4      | 3-row              | 4                | 15.8                 | 2.6                  | 5.0                | 0.7                              |
|  | 50     | 4-row              | 2                | 14.0                 | 1.6                  | 3.3                | 0.9                              |
|  | 6      | 4-row              | 4                | 21.9                 | 1.9                  | 4.0                | 0.5                              |
|  | 9      | 5-row              | 2                | 16.5                 | 1.3                  | 2.6                | 0.7                              |
| Planting                                   |        |                    |                  |                      |                      |                    |                                  |
| Drilling grain . . . . .                   | 4      | 5-foot             | 2                | 12.7                 | 1.7                  | 3.1                | 1.0                              |
|  | 44     | 6-foot             | 2                | 10.9                 | 1.9                  | 3.4                | 1.0                              |
|  | 12     | 6-foot             | 3                | 11.7                 | 2.6                  | 4.8                | 1.0                              |
|  | 6      | 6-foot             | 4                | 13.1                 | 3.0                  | 5.7                | 0.9                              |
|  | 17     | 7-foot             | 2                | 11.2                 | 1.9                  | 3.3                | 1.0                              |
|  | 7      | 7-foot             | 3                | 12.6                 | 2.6                  | 4.8                | 0.9                              |
|  | 5      | 7-foot             | 4                | 13.3                 | 3.2                  | 5.6                | 0.9                              |
|  | 7      | 8-foot             | 2                | 11.7                 | 1.8                  | 3.1                | 0.9                              |
|  | 12     | 8-foot             | 3                | 13.5                 | 2.3                  | 4.2                | 0.8                              |
|  | 27     | 8-foot             | 4                | 14.9                 | 2.9                  | 5.3                | 0.8                              |
|  | 5      | 10-foot            | 4                | 14.0                 | 3.2                  | 5.9                | 0.8                              |

<sup>1/</sup> Includes servicing of machines, but no chore labor, and more (Continued)  
than one-man crew where used.



Table 33.- Summary of horse field operations, three major irrigated areas, southern Idaho, 1940 (Continued)

| Field operation               | Cases  | Width of implement | Number of horses | Work per 10-hour day | Horse: hours per acre | Equiv.: HP hrs. per acre | Man- hours per acre <sup>1/</sup> |
|-------------------------------|--------|--------------------|------------------|----------------------|-----------------------|--------------------------|-----------------------------------|
|                               | Number |                    | Number           | Acres                | Hours                 | EHP hr.                  | Hours                             |
| Planting                      |        |                    |                  |                      |                       |                          |                                   |
| Planting potatoes             | 75     | 1-row              | 2                | 5.4                  | 4.0                   | 8.0                      | 2.2                               |
|                               | 5      | 2-row              | 4                | 10.3                 | 4.0                   | 7.9                      | 1.2                               |
| Planting beets                | 85     | 4-row              | 2                | 12.1                 | 1.8                   | 4.4                      | 0.9                               |
| Planting beans                | 64     | 4-row              | 2                | 14.2                 | 1.5                   | 4.3                      | 0.8                               |
| Planting peas (drill)         | 7      | 8-foot             | 4                | 12.3                 | 3.0                   | 4.9                      | 0.9                               |
| Planting peas (planter)       | 12     | 4-row              | 2                | 11.0                 | 2.0                   | 3.3                      | 1.0                               |
| Planting corn                 | 44     | 2-row              | 2                | 10.2                 | 2.2                   | 5.0                      | 1.1                               |
|                               | 4      | 4-row              | 2                | 11.8                 | 1.8                   | 4.1                      | 0.9                               |
| Planting vegetable seed crops | 11     | 4-row              | 2                | 10.1                 | 2.1                   | 3.6                      | 1.1                               |
| Cultivating potatoes          | 62     | 1-row              | 2                | 6.3                  | 3.4                   | 5.2                      | 1.7                               |
| Cultivating beets             | 76     | 4-row              | 2                | 11.4                 | 1.8                   | 4.5                      | 0.9                               |
| Cultivating beans             | 51     | 4-row              | 2                | 14.3                 | 1.5                   | 3.9                      | 0.8                               |
| Cultivating corn              | 31     | 1-row              | 2                | 5.8                  | 3.6                   | 6.6                      | 1.8                               |
|                               | 6      | 2-row              | 2                | 8.1                  | 3.5                   | 6.1                      | 1.4                               |
| Cultivating vegetables        | 13     | 4-row              | 2                | 10.7                 | 2.1                   | 4.5                      | 0.9                               |
| Harvesting                    |        |                    |                  |                      |                       |                          |                                   |
| Mowing alfalfa                | 113    | 5-foot             | 2                | 9.9                  | 2.1                   | 4.4                      | 1.1                               |
|                               | 11     | 6-foot             | 2                | 11.3                 | 1.8                   | 3.6                      | 1.0                               |
| Raking hay                    | 20     | 7-foot             | 2                | 17.8                 | 1.2                   | 2.8                      | 0.6                               |
|                               | 37     | 8-foot             | 2                | 16.9                 | 1.3                   | 3.0                      | 0.6                               |
|                               | 41     | 9-foot             | 2                | 17.5                 | 1.3                   | 3.0                      | 0.6                               |
|                               | 16     | 10-foot            | 1                | 20.8                 | 0.6                   | 1.4                      | 0.5                               |
|                               | 104    | 10-foot            | 2                | 18.8                 | 1.2                   | 2.9                      | 0.6                               |
|                               | 18     | 12-foot            | 2                | 18.7                 | 1.2                   | 3.1                      | 0.6                               |

<sup>1/</sup> Includes servicing of machines, but no chore labor, and more than one-man crew where used.

(Continued)

Table 33.- Summary of horse field operations, three major irrigated areas, southern Idaho, 1940 (Continued)

| Field operation                | Cases  | Width of implement | Number of horses | Work per 10-hour day | Horse per hours | Equiv. HP per acre | Man-hours per acre <sup>1/</sup> |
|--------------------------------|--------|--------------------|------------------|----------------------|-----------------|--------------------|----------------------------------|
|                                | Number |                    | Number           | Acres                | Hours           | EHP hr.            | Hours                            |
| Harvesting                     |        |                    |                  |                      |                 |                    |                                  |
| Bunching hay . . .             | 8      | 8-foot             | 2                | 18.9                 | 1.1             | 2.4                | 0.6                              |
|                                | 29     | 9-foot             | 2                | 17.8                 | 1.2             | 2.6                | 0.6                              |
|                                | 92     | 10-foot            | 2                | 19.6                 | 1.1             | 2.5                | 0.5                              |
|                                | 10     | 12-foot            | 2                | 18.1                 | 1.2             | 2.7                | 0.6                              |
| Binding grain . . .            | 26     | 6-foot             | 3                | 10.4                 | 3.1             | 6.1                | 1.1                              |
|                                | 10     | 6-foot             | 4                | 12.0                 | 3.5             | 6.7                | 1.0                              |
|                                | 6      | 7-foot             | 4                | 12.6                 | 3.4             | 6.5                | 0.9                              |
| Digging potatoes . .           | 19     | 1-row              | 4                | 4.1                  | 10.3            | 16.8               | 2.7                              |
| Lifting beets . . .            | 56     | 1-row              | 2                | 3.1                  | 6.8             | 13.9               | 3.5                              |
|                                | 19     | 1-row              | 3                | 3.5                  | 9.3             | 19.1               | 3.1                              |
|                                | 10     | 1-row              | 4                | 3.9                  | 10.4            | 20.9               | 2.9                              |
| Cutting beans . . .            | 26     | 2-row              | 2                | 8.9                  | 2.5             | 4.2                | 1.2                              |
|                                | 27     | 4-row              | 2                | 13.2                 | 1.6             | 2.8                | 0.9                              |
| Raking beans . . .             | 14     | 7-foot             | 2                | 17.5                 | 1.3             | 3.1                | 0.7                              |
|                                | 15     | 8-foot             | 2                | 15.2                 | 1.5             | 3.6                | 0.8                              |
|                                | 22     | 10-foot            | 2                | 13.7                 | 1.5             | 3.5                | 0.8                              |
| Cutting peas (mower) . . . . . | 14     | 5-foot             | 2                | 7.1                  | 3.5             | 7.1                | 1.5                              |
| Lifting onions . . .           | 10     | 2-row              | 2                | 5.0                  | 4.2             | 7.8                | 2.1                              |

<sup>1/</sup> Includes servicing of machines, but no chore labor, and more than one-man crew where used.

Table 34.- Horsepower developed on farms having one tractor, by size and extent of annual use of tractor, three major irrigated areas, southern Idaho, 1940

| Size of tractor (DBHP) | Hours of use   | Number of records | Average rating of tractor | Average number of hours used | Average horsepower all work | Average horsepower developed |
|------------------------|----------------|-------------------|---------------------------|------------------------------|-----------------------------|------------------------------|
|                        |                | Number            | DBHP                      | Hours                        | HP hr.                      | HP                           |
| Under 10 . . . . .     | Under 200      | 3                 | 9.74                      | 177                          | 1,174                       | 6.6                          |
|                        | 200 - 399      | 22                | 9.54                      | 308                          | 2,329                       | 7.6                          |
|                        | 400 - 599      | 19                | 9.47                      | 498                          | 3,612                       | 7.3                          |
|                        | 600 - 799      | 9                 | 9.55                      | 723                          | 5,470                       | 7.6                          |
|                        | 800 - 999      | 3                 | 9.07                      | 842                          | 5,609                       | 6.7                          |
|                        | 1,000 - 1,199  | 3                 | 9.45                      | 1,088                        | 8,219                       | 7.6                          |
|                        | 1,200 and over | --                | --                        | --                           | --                          | --                           |
| Average . . . . .      |                | 59                | 9.50                      | 493                          | 3,629                       | 7.4                          |
| 10-14.99 . . . . .     | Under 200      | 18                | 12.76                     | 140                          | 1,201                       | 8.6                          |
|                        | 200 - 399      | 34                | 12.11                     | 298                          | 2,364                       | 7.9                          |
|                        | 400 - 599      | 25                | 12.11                     | 474                          | 4,040                       | 8.5                          |
|                        | 600 - 799      | 11                | 12.20                     | 685                          | 5,825                       | 8.5                          |
|                        | 800 - 999      | 7                 | 12.89                     | 898                          | 7,502                       | 8.4                          |
|                        | 1,000 - 1,199  | 2                 | 10.76                     | 1,104                        | 12,086                      | 10.9                         |
|                        | 1,200 and over | 1                 | 13.56                     | 1,305                        | 13,386                      | 10.3                         |
| Average . . . . .      |                | 98                | 12.31                     | 427                          | 3,645                       | 8.5                          |
| 15-19.99 . . . . .     | Under 200      | 11                | 17.05                     | 146                          | 1,698                       | 11.6                         |
|                        | 200 - 399      | 32                | 17.50                     | 286                          | 3,262                       | 11.4                         |
|                        | 400 - 599      | 12                | 17.13                     | 499                          | 5,592                       | 11.2                         |
|                        | 600 - 799      | 15                | 17.61                     | 670                          | 8,299                       | 12.4                         |
|                        | 800 - 999      | 7                 | 17.33                     | 869                          | 10,672                      | 12.3                         |
|                        | 1,000 - 1,199  | 4                 | 17.01                     | 1,094                        | 12,863                      | 11.8                         |
|                        | 1,200 and over | 1                 | 19.13                     | 2,008                        | 22,641                      | 11.3                         |
| Average . . . . .      |                | 82                | 17.39                     | 479                          | 5,652                       | 11.8                         |
| 20-24.99 . . . . .     | Under 200      | 2                 | 20.27                     | 142                          | 2,306                       | 16.2                         |
|                        | 200 - 399      | 8                 | 21.93                     | 295                          | 4,390                       | 14.9                         |
|                        | 400 - 599      | 5                 | 21.69                     | 470                          | 7,265                       | 15.5                         |
|                        | 600 - 799      | 2                 | 22.64                     | 691                          | 10,183                      | 14.7                         |
|                        | 800 - 999      | 1                 | 22.64                     | 865                          | 15,231                      | 17.6                         |
|                        | 1,000 - 1,199  | --                | --                        | --                           | --                          | --                           |
|                        | 1,200 and over | --                | --                        | --                           | --                          | --                           |
| Average . . . . .      |                | 18                | 21.80                     | 103                          | 6,203                       | 15.4                         |

(Continued)



Table 34.- Horsepower developed on farms having one tractor, by size and extent of annual use of tractor, three major irrigated areas, southern Idaho, 1940 (Continued)

| Size of tractor (DBHP) | Hours of use   | Number of records | Average rating of tractor | Average number of hours used | Average horse-power all work | Average horse-power developed |
|------------------------|----------------|-------------------|---------------------------|------------------------------|------------------------------|-------------------------------|
|                        |                | Number            | DBHP                      | Hours                        | HP hr.                       | HP                            |
| 25 and over . . . .    | Under 200      | 1                 | 25.11                     | 153                          | 2,545                        | 16.6                          |
|                        | 200 - 399      | --                | --                        | --                           | --                           | --                            |
|                        | 400 - 599      | 1                 | 28.97                     | 553                          | 9,075                        | 16.4                          |
|                        | 600 - 799      | --                | --                        | --                           | --                           | --                            |
|                        | 800 - 999      | --                | --                        | --                           | --                           | --                            |
| Average . . . . .      |                | 2                 | 27.04                     | 353                          | 5,810                        | 16.5                          |
| All sizes . . . . .    | Under 200      | 35                | 14.63                     | 146                          | 1,457                        | 10.0                          |
|                        | 200 - 399      | 96                | 14.14                     | 296                          | 2,637                        | 8.9                           |
|                        | 400 - 599      | 62                | 13.36                     | 487                          | 4,551                        | 9.3                           |
|                        | 600 - 799      | 37                | 14.31                     | 689                          | 6,977                        | 10.1                          |
|                        | 800 - 999      | 18                | 14.52                     | 876                          | 8,849                        | 10.1                          |
|                        | 1,000 - 1,199  | 9                 | 11.32                     | 1,094                        | 11,143                       | 10.2                          |
|                        | 1,200 and over | 2                 | 16.35                     | 1,657                        | 18,014                       | 10.9                          |
| Average . . . . .      |                | 259               | 14.05                     | 456                          | 4,471                        | 9.8                           |

Table 35.- Number of farms having one tractor each, by type of farm, and by size and extent of annual use of tractor, three major irrigated areas, southern Idaho, 1940

| Type of farm<br>and<br>size of tractor | Extent of annual use of tractor |     |     |     |     |       |        |   | All<br>groups |
|--|---------------------------------|-----|-----|-----|-----|-------|--------|---|---------------|
|  | Under                           | 200 | 400 | 600 | 800 | 1,000 | 1,200  |   |               |
|  | 200                             | to  | to  | to  | to  | to    | hours  |   |               |
|  | Hr.                             | 399 | 599 | 799 | 999 | 1,199 | & over |   |               |
| Livestock farms                        | :                               | :   | :   | :   | :   | :     | :      | : | :             |
| Under 10 HP . . . . .                  | 1                               | --  | 3   | 1   | --  | --    | --     |   | 5             |
| 10-14.99 HP . . . . .                  | 4                               | 4   | 2   | 2   | --  | --    | --     |   | 12            |
| 15-19.99 HP . . . . .                  | 2                               | 7   | 2   | --  | --  | 1     | --     |   | 12            |
| 20-24.99 HP . . . . .                  | 1                               | 1   | 2   | --  | --  | --    | --     |   | 4             |
| 25 HP and over . . . . .               | --                              | --  | --  | --  | --  | --    | --     |   | --            |
| All sizes . . . . .                    | 8                               | 12  | 9   | 3   | --  | 1     | --     |   | 33            |
| Cash-crop farms                        | :                               | :   | :   | :   | :   | :     | :      | : | :             |
| Under 10 HP . . . . .                  | 1                               | 9   | 8   | 7   | --  | 1     | --     |   | 26            |
| 10-14.99 HP . . . . .                  | 10                              | 21  | 11  | 7   | 5   | 2     | --     |   | 56            |
| 15-19.99 HP . . . . .                  | 6                               | 18  | 4   | 3   | 2   | --    | 1      |   | 34            |
| 20-24.99 HP . . . . .                  | --                              | 5   | 2   | 2   | 1   | --    | --     |   | 10            |
| 25 HP and over . . . . .               | 1                               | --  | --  | --  | --  | --    | --     |   | 1             |
| All sizes . . . . .                    | 18                              | 53  | 25  | 19  | 8   | 3     | 1      |   | 127           |
| Mixed cash-crop-<br>livestock farms    | :                               | :   | :   | :   | :   | :     | :      | : | :             |
| Under 10 HP . . . . .                  | 1                               | 13  | 8   | 1   | 3   | 2     | --     |   | 28            |
| 10-14.99 HP . . . . .                  | 4                               | 9   | 12  | 2   | 2   | --    | 1      |   | 30            |
| 15-19.99 HP . . . . .                  | 3                               | 7   | 6   | 12  | 5   | 3     | --     |   | 36            |
| 20-24.99 HP . . . . .                  | 1                               | 2   | 1   | --  | --  | --    | --     |   | 4             |
| 25 HP and over . . . . .               | --                              | --  | 1   | --  | --  | --    | --     |   | 1             |
| All sizes . . . . .                    | 9                               | 31  | 28  | 15  | 10  | 5     | 1      |   | 99            |
| All farms                              | :                               | :   | :   | :   | :   | :     | :      | : | :             |
| Under 10 HP . . . . .                  | 3                               | 22  | 19  | 9   | 3   | 3     | --     |   | 59            |
| 10-14.99 HP . . . . .                  | 18                              | 34  | 25  | 11  | 7   | 2     | 1      |   | 98            |
| 15-19.99 HP . . . . .                  | 11                              | 32  | 12  | 15  | 7   | 4     | 1      |   | 82            |
| 20-24.99 HP . . . . .                  | 2                               | 8   | 5   | 2   | 1   | --    | --     |   | 18            |
| 25 HP and over . . . . .               | 1                               | --  | 1   | --  | --  | --    | --     |   | 2             |
| All sizes . . . . .                    | 35                              | 96  | 62  | 37  | 18  | 9     | 2      |   | 259           |